Organizational Roles and Communication Modes in Team Work

Antonios Michailidis
Computer Science Department
State University of New York at Stony Brook
Stony Brook, NY 11794-4400
email: antonios@cs.sunysb.edu

Roy Rada
Department of Information Systems
University of Maryland, Baltimore County
1000 Hilltop Circle, Baltimore, MD 21250
email: rada@umbc.edu

Abstract

We have surveyed ten collaborators' perceptions on the value of nine communication modes: email, telephone, pen-and-paper, computer conferencing, telephone conferencing, face-to-face, fax, post, and whiteboard. Eight roles were considered: innovator, resource investigator, chair, shaper, evaluator, team worker, organizer, and finisher. Through a repeated measures design, a mapping between these modes and roles was determined. Face-to-face communication was viewed as most valuable by all roles, except the innovator role. Voice-based communication modes supported more interdependencies among roles than any other communication mode, but each mode serves a function in supporting group work.

1. Introduction

People employ a variety of communication modes to coordinate groupwork. Coordination is, according to Malone's definition of the term, "the act of working together harmoniously" [12]. Coordination of a group's activities is necessary to enhance the effectiveness of cooperation among the members of the group and adjust individual work efforts towards the attainment of the group's shared goal [4].

Two approaches towards defining coordination activities have been proposed in the literature. In the first approach coordination activities are defined as a function of collaborative activities [12]. The second approach views coordination activities as a function of the social roles that co-workers perform [16]. Social roles determine responsibilities and patterns of interaction among group members.

Communication modes should be "in synch" with the tasks the group is trying to accomplish. Work groups that require communication within the work group or between the work group and other work groups may be able to coordinate their work more effectively when they use technology that fits their communication task structure. The above speculations are consistent with structural contingency theory and the theory of media richness.

Structural contingency theory suggests that, to be effective, a work group must fit its technology to the structure of its tasks. Structural contingency theory provides a heuristic framework for analyzing the influence of information technology on work group effectiveness. In its most general form, this theory proposes that, to be effective, an organization must conform to its context [10]. Three types of context have been studied: environment, size and technology. Structural contingency theory can be expressed in terms of the following relationships:

- between the organization's technology and its structural characteristics, and
- the relationship between this "fit" and the organization's effectiveness.

The theory of media richness says that rich media are more appropriate for performing communication tasks that are characterized by equivocality while less rich media may be appropriate for tasks that are characterized by uncertainty. Uncertainty means absence of information and has been defined as ``the difference between the amount of information required to perform the task and the amount of information already possessed by the group" [7] cited in [2]. Equivocality means ambiguity and is characterized by multiple and/or conflicting interpretations of the available information. The richness of a medium depends on the medium's capacity for feedback, the number of cues conveyed, personalization, and language variety [1].

In any work group, the roles that individual participants play dictate different practices [5], [6] and use of the available communication modes towards the

completion of the work [27], [14], [13]. This paper has two main objectives. First, to investigate the "fit" and relationships between the social-roles that people perform in a group and the communication modes they use. Second, to identify the characteristics or attributes of communication modes that differentiate them from one another and make them appropriate for certain roles.

What communication modes are appropriate for what roles? Answering this question correctly is vital to the design of quality group work systems. We carefully specify the roles and modes and then experimentally develop a mapping between roles and modes.

People may adopt different roles in the course of their teamwork. Using the classification of roles suggested by Platt et al in [19], a manager may also act as a finisher in the course of his/her work, a team worker may chair a subgroup meeting, and so on. We adopted general (i.e. not associated with a specific collaborative task) classes of roles based on co-workers' skills required in various collaborative situations. The following roles are considered in this study [19]:

- **Innovator:** Thinks up new ideas.
- **Resource Investigator:** Brings information and ideas to the team but from sources outside the group.
- **Chair:** The social leader of the group whose skill lies in spotting what each member does best and in guiding the team towards success.
- **Shaper:** Provides the energy and drive to implement the ideas and get projects moving.
- **Evaluator:** Critically appraises proposals and monitors progress and prevents the group from making mistakes.
- **Team Worker:** Unites by providing an informal network of communication and support which continues outside meetings.
- **Organizer:** Translates plans into manageable tasks.
- **Finisher:** Makes sure the group delivers.

Numerous communication modes are used by people. Popular new modes are those supported by technologies, such as computer conferencing. The range of modes includes email, telephone, pen-and-paper, computer conferencing, telephone conferencing, face-to-face meetings, fax, post, and whiteboard.

This paper presents one systematic study of the fit between communication mode and group roles. The study fits the traditional scientific model. We present next the research method, results, and discussion, in that order.

2. Research Method

A questionnaire was distributed to a group of professionals who worked on a large Commission of the European Communities project. The questionnaire was given to the subjects during a project meeting. Ten people responded to the questionnaire. Six of them worked in industry and four in academia. All participants were IT experts. The respondents worked in UK and Italy and collaborated in the design, implementation, and field-testing of a large software system.

The questionnaire focused on communication modes that people use and on roles they play. It consisted of eight parts. Each part included statements centered on the following communication modes: email, telephone, pen-and-paper, computer conferencing, telephone conferencing, face-to-face, fax, post, and whiteboard. The subjects were asked to judge the value (on a 7-point Likert scale) of each of those communication modes against eight types of roles (innovator, resource investigator, chair, shaper, evaluator, team worker, organizer, and finisher) that they had experienced in a group context. They were instructed to respond only to questions pertinent to roles they experienced in their jobs and to communication modes they used in the past.

The questionnaire was preceded by a detailed example on how to complete it. Subjects were told that there were no right or wrong answers and that this questionnaire was not a test. Subjects' anonymity was assured. To encourage subjects to fill the questionnaire, they were told that the results would be used for guidance in the management of the project. The subjects were requested to judge the value of modes against the role variables. Definitions of terms were also supplied.

3. Results

In the following subsections the results of the analysis are presented. In the first subsection, ``Roles", descriptive statistics on how the subjects judged the value of communication modes to social roles are presented. The significance of the subjects' judgments is evaluated, and the modes that best fit individual roles are identified. In the ``Role Interdependencies" subsection, the interdependencies between roles supported by each value of the communication mode variable are identified. Finally, in the subsection ``Communication Modes Characteristics" the differences and similarities between the communication modes characteristics are examined.

3.1. Roles

The subjects' responses are summarized in Tables 1, 2, and 3. The respondents felt that the most valuable communication mode for the innovator is pen-and-paper and the least valuable is post. It is striking that the three most valuable modes for the innovator are the most primitive ones (pen-and-paper, whiteboard, and face-to-

face). Face-to-face received the highest scores for the other roles. Computer-based communication modes such as email and computer conferencing, were also rated highly for the evaluator, organizer, and finisher roles.

Table 1. Roles and communication modes. Summary of results for innovator, resource investigator, and chair. Highest scores are shaded.

	Roles									
	Innovator			Res. Investigator			Chair			
Mode[1]	**mean**	**sd**	**range**	**mean**	**sd**	**range**	**mean**	**sd**	**range**	**N**
Email	4.22	1.86	2-7	5.22	1.56	3-7	5.00	1.32	3-7	9
Phone	3.78	1.64	2-7	4.33	1.66	2-7	4.44	1.51	2-6	9
PP	5.78	1.09	4-7	3.11	1.76	1-6	3.22	1.48	1-5	9
CC	5.22	1.30	3-7	4.89	1.54	2-7	4.78	1.39	3-7	9
TC	4.13	1.36	2-6	3.75	1.04	2-5	4.50	1.31	3-7	8
FtF	5.56	1.59	3-7	5.56	1.33	3-7	5.56	1.42	4-7	9
Fax	3.56	1.42	2-6	4.44	1.67	2-7	3.78	1.56	1-5	9
Post	2.89	0.78	2-4	4.22	1.30	2-6	3.56	1.13	2-5	9
WB	5.67	1.12	4-7	3.89	2.09	1-7	4.33	2.29	1-7	9

Table 2. Roles and communication modes. Summary of results for shaper, evaluator, and team worker. Highest scores are shaded.

	Roles									
	Shaper			Evaluator			Team Worker			
Mode	**mean**	**sd**	**range**	**mean**	**sd**	**range**	**mean**	**sd**	**range**	**N**
Email	5.00	1.87	1-7	5.11	1.36	4-7	5.44	2.13	1-7	9
Phone	4.56	2.01	1-7	4.33	1.41	2-7	4.56	1.88	2-7	9
PP	5.44	1.33	3-7	3.67	1.73	1-6	4.33	2.24	1-7	9
CC	5.22	1.39	3-7	5.56	1.59	3-7	5.33	1.58	3-7	9
TC	4.25	1.16	3-6	4.25	1.75	2-7	3.63	1.30	2-5	8
FtF	5.56	1.33	3-7	5.56	1.51	3-7	6.22	0.97	4-7	9
Fax	4.33	1.22	3-6	4.33	1.32	2-6	4.22	0.83	3-5	9
Post	3.78	1.09	2-6	3.67	1.00	2-5	3.33	1.12	2-5	9
WB	5.00	1.50	2-7	3.67	2.24	1-7	4.44	2.24	1-7	9

Table 3. Roles and communication modes. Summary of results for organizer and finisher. Highest scores are shaded

	Roles						
	Organizer			Finisher			
Mode	**mean**	**sd**	**range**	**Mean**	**sd**	**range**	**N**
Email	4.89	1.54	2-7	4.89	1.76	2-7	9
Phone	4.78	1.79	2-7	5.00	1.73	2-7	9
PP	4.89	1.36	2-6	3.78	1.92	1-7	9
CC	5.00	1.58	3-7	4.33	2.12	1-7	9
TC	4.13	1.55	2-7	3.88	2.03	1-7	8
FtF	5.89	1.27	4-7	5.00	2.00	1-7	9
Fax	4.33	1.58	1-6	4.00	1.66	1-7	9
Post	3.56	1.13	1-5	3.78	1.56	1-6	9
WB	4.78	1.86	2-7	3.44	1.81	1-7	9

[1]CC: computer conferencing; TC: telephone conferencing; PP: pen-and-paper; FtF: face-to-face; WB: whiteboard.

For each role variable, a two-way Friedman ANOVA test has been performed in order to investigate whether the subjects' evaluations of communication modes differ significantly. The results suggested significant differences in the subjects' evaluations of communication modes under the innovator and team worker roles (see Table 4). That is, in a group context, the innovator and team worker perceive some of the communication modes as more valuable to them in doing their work. The subjects felt that they would not prefer one of the communication modes to another during the course of performing the other six roles.

The Friedman test indicated only whether there were significant differences in the subjects' evaluations of communication modes, but it did not pinpointed the communication modes which have been rated as the most valuable under each role variable. The Wilcoxon matched-pairs signed-ranks test was employed to make paired comparisons between the communication modes rankings for the innovator and team worker roles in order to determine the most valuable communication modes for these two roles.

Table 4. Mean ranks for each value of the communication mode variable under the eight role variables. **Communication Mode**: PP: Pen-and-paper; CC: Computer Conferencing; TC: Telephone Conferencing; FtF: Face-to-Face; WB: Whiteboard. **Roles:** Inn: Innovator; ResIn: Resource Investigator; Shap: Shaper; Eval: Evaluator; TW: Team Worker; Org: Organizer; Fin: Finisher. The statistically significant results are written in bold-italics.

Mode	**Roles**							
	Inn	**ResIn**	**Chair**	**Shap**	**Eval**	**TW**	**Org**	**Fin**
Email	3.88	5.75	6.19	5.75	5.75	6.25	5.69	6.50
Phone	3.00	4.19	5.69	4.63	5.13	5.38	5.06	6.56
PP	7.50	3.44	3.06	6.25	3.69	4.50	5.56	4.31
CC	5.69	6.13	5.69	5.63	6.38	5.75	6.06	4.94
TC	4.44	4.25	4.81	4.06	4.75	3.56	4.31	4.19
FtF	7.31	6.81	7.00	6.44	6.81	7.56	7.00	6.00
Fax	3.31	5.06	4.00	3.06	5.00	4.50	3.88	4.50
Post	2.63	5.25	4.00	3.31	3.75	3.19	2.69	4.31
WB	7.25	4.13	4.56	5.88	3.75	4.31	4.75	3.69
c^2	33.28	10.25	13.16	13.87	11.38	16.17	13.94	9.89
N	8 *9*	8 *9*	8 *9*	8 *9*	8 *9*	8 *9*	8 *9*	8 *9*
df	8 *4*	8 *4*	8 *4*	8 *4*	8 *4*	8 *4*	8 *4*	8 *4*
p	***0.00***	0.25	0.11	0.09	0.18	***0.04***	0.08	0.27

For the innovator role the results indicate that computer conferencing, pen-and-paper, whiteboard, and face-to-face are the most valuable communication modes (see Figure 1). For the team worker role face-to-face, email, and computer conferencing are more valuable than the rest of the communication modes examined (see Figure 2).

3.2. Role Interdependencies

Spearman's rank-difference correlation coefficient was used to identify the positive interdependencies between roles for each value of the communication mode variable. A positive interdependency between a pair of roles meant that the relationship between the two roles was such that when communication mode support for one role increased then support for the other role would increase by a predictable amount indicated by the Spearman's rho correlation coefficient.

The examined set of communication modes seems to support all the possible interdependencies between roles (see Figure 3). Face-to-face and phone support more interdependencies than any other communication mode, 26 and 15 respectively. This result suggests that face-to-face and phone are the richest modes to support interactions between roles. The subjects perceived that whiteboard is particularly useful in supporting the interdependencies between the team worker and the rest of the roles.

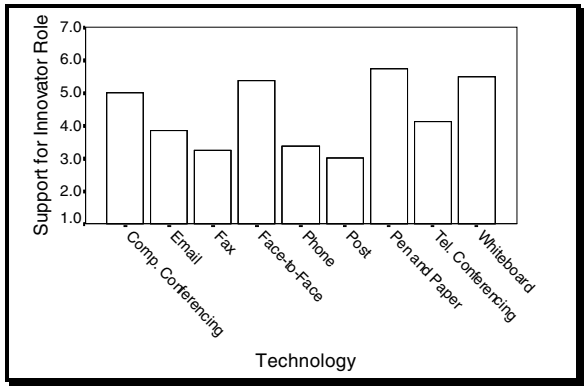

Figure 1. Bar chart representing the mean scores of the examined communication modes for the innovator role.

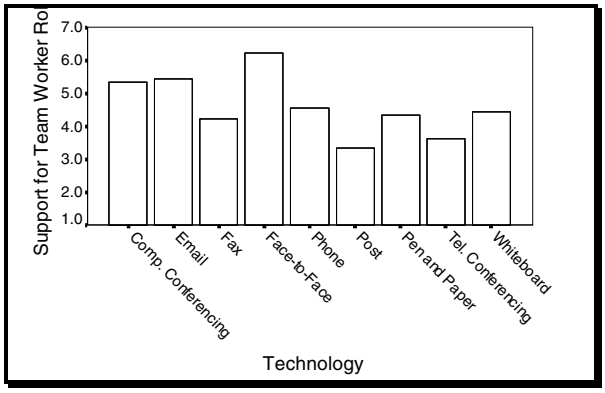

Figure 2. Bar chart representing the mean scores of the examined communication modes for the team worker role.

	Team Worker	Res. Invest.	Innovator	Finisher	Shaper	Organiser	Evaluator	Chair
Chair								
Evaluator								FtF
Organiser							FtF Post Phone	Email TC Fax FtF Phone
Shaper						FtF TC Phone	CC TC Email FtF	FtF
Finisher						CC TC Fax FtF Phone	FtF WB Phone TC	Email FtF
Innovator				FtF TC Phone	Email PP FtF Phone	Fax TC FtF Phone	FtF Email	Fax TC FtF *PP*
Res. Invest.			FtF *PP* Phone	FtF WB Phone	FtF	FtF Phone	WB FtF PP *Post*	FtF PP Phone
Team Worker		CC FtF WB	CC WB FtF Phone	FtF WB	Email Post Fax Phone	Fax FtF Phone	CC Email FtF WB	Fax FtF

Figure 3. Communication mode support for interdependencies between roles. For each pair of roles the modes that support it are stated. The modes in italics indicate a negative correlation between the corresponding roles.

Two negative correlations between resource investigator and innovator and between innovator and chair have been derived when people use pen-and-paper. Furthermore, a negative correlation between resource investigator and evaluator has been observed when role agents use post to interact. Pen-and-paper and post are the least valued communication modes in the interactions between the above pairs of roles. The communication modes differ in the number of interdependencies they support. Communication modes overlap in the kinds of interdependencies they support. In the following subsections the differences and similarities between the examined modes are investigated.

3.3. Communication Modes Characteristics

Principal components factor analysis with varimax rotation has been performed to identify the factors that explain the differences in the number and kinds of role interdependencies supported by the communication modes. The purpose of factor analysis is to extract from the collected data, for each communication mode, the factors (or aspects) of role activities that are best supported by a particular communication mode. Each factor corresponds to and is expressed as a linear combination of a subset of the original role variables. The evaluation tests on the appropriateness of factor analysis showed that factor analysis is appropriate only for the face-to-face communication mode (KMO = 0.50 - BTS = 74.85, p = 0.00).

The factor analysis for face-to-face produced only one factor. This result suggests that face-to-face is a valuable communication mode in coordinating teamwork when coordination is defined as a function of the social roles that collaborators play. Indeed, reliability analysis shows that the eight role variables constitute a reliable measure of coordination with face-to-face (Cronbach's alpha = 0.96).

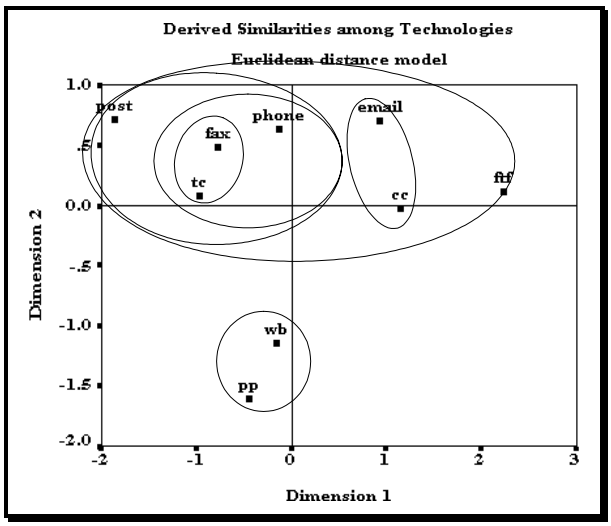

Figure 4. Similarities among the communication modes. tc: telephone conferencing; cc: computer conferencing; ftf: face-to-face; pp: pen-and-paper; wb: whiteboard.

In addition to the differences between the communication modes, we investigated the similarities among them in terms of their support for coordination. Hierarchical cluster analysis was used to identify relatively homogeneous groups of communication modes. Multidimensional scaling was used to represent modes in a two-dimensional space where the locations of the modes were estimated from matrices of distances between pairs of modes.

To derive the similarities between the communication modes, multidimensional scaling analysis has been performed. The two-dimensional solution (stress = 0.07, RSQ = 0.99) (see Figure 4) produced by the analysis does not lead to definitive conclusions. The horizontal dimension may be interpreted as the degree of interactivity supported by the communication modes. For instance, face-to-face, phone and email are perceived as more interactive than pen-and-paper, post, and fax. The vertical dimension may be interpreted as mode expressiveness. Hand-written and voice media are characterized by immediacy in expressing information that collaborators have in their minds. For instance, whiteboard, pen-and-paper, and face-to-face allow immediate expression and presentation of information to others.

The solution produced by the hierarchical clustering procedure is shown in Figure 4. Communication modes that are homogeneous are encircled. Three different clusters of homogeneous modes have been produced: (i) voice media, (ii) written media, and (iii) computer text-based media

The results indicate that the above types of communication modes differ from each other in the support they provide to coordination activities associated with roles that collaborators play. Furthermore, the results seem to confirm that face-to-face communication differs from all the other communication modes which have been examined here and is the most valuable form of interaction between roles.

4. Discussion

We have carefully examined 9 communication modes relative to 8 roles in a group. The results of our experiment suggest that a person's perception of the value of a communication mode is a function of the person's role. The results also indicate that the subjects perceived that communication modes are complementary in their support for roles. The need for multi-channel interaction and switching has been reported in the literature [22] and emphasizes the complementary nature of different communication modes in performing a single task [3], [26]. However, face-to-face communication was viewed most positively by all roles except the innovator role.

When coordination is expressed as a function of the social roles that collaborators play in a group context,

then the choice of communication mode might affect group coordination. The modes differ in their support for both the roles that collaborators play and the interdependencies between roles. Voice-based communication modes (face-to-face and phone) were found to support more positive interdependencies among roles than any of the other communication modes examined. Voice-based modes were also considered valuable for organizing the work and for making sure that the work is completed in time.

This result confirms early research findings which suggested that the inclusion of a voice channel in cooperative problem-solving may lead to effective cooperation and to decreases in communication time [18]. However, none of the examined communication modes was capable of providing support for the full range of the possible interdependencies between roles. This may attributed to the fact that the communication modes are not collaboration aware - they mediate interactions without regard to the communication and information processing requirements of group members' social roles [23].

Face-to-face was considered the most valuable communication mode for all roles except the innovator role. Pen-and-paper and whiteboard were considered as the most valuable for the innovator. The innovator role requires creativity and at the early stages of the process of thinking up new ideas it may require privacy. Both pen-and-paper and whiteboard provide a private workspace and are characterized by expressiveness and immediacy. The other roles require interactivity, which is best supported by face-to-face.

That face-to-face is the most powerful communication mode is consistent with findings reported in the literature. Galegher and Kraut [8] studied the effect of communication modes on group writing. They reported that computer-mediated communication, as compared with face-to-face communication, inhibits interactivity and reduces awareness and commitment. They also noted that the addition of telephone to computer conferencing only partially mitigates the limitations of computer conferencing.

Email may increase the volume, speed, and regularization of communication, while on the other hand it may incur redundancy and information overload [25]. Successful use of email may depend both on the task and the role of the user and his or her environment. Email may be particularly effective for the coordination of loosely-coupled asynchronous activities [24].

The choice of mode that collaborators make in order to perform efficiently the roles they assume may be determined the degree of interactivity and expressiveness that characterizes a particular mode. Interactivity relies on the communication mode's capacity for immediate feedback. Expressiveness is a function of communication mode's capacity on conveying personal feelings and emotions, voice intonation, multiple communication channels, body gestures, and language variety.

Three types of homogeneous technologies, in terms of their support of roles, have been identified:

- voice technologies (telephone and telephone conferencing),
- written technologies (whiteboard and pen-and-paper), and
- computer text-based technologies (email and computer conferencing).

The identified patterns of relations among roles show that face-to-face supports more relations among roles than any other communication mode. This indicates the potential inadequacy of the examined communication modes to support social and organizational aspects of group work. Groupware should complement existing technologies, while maintaining the support that face-to-face provides.

Building systems that restrict the choice of communication modes may lead to their rejection [9], [15] and decrease group performance. However, it has been reported that groups involved in equivocal tasks may adapt their communication behavior to overcome the communication medium constraints and also perceive that actual task outcomes are better than those that would result by using a richer communication medium [11]. A useful system provides multiple modes of communication and supports flexibility in the selection and switching of the appropriate communication modes at any given time [21], [20].

The results of this study should be treated with caution and considered as suggestive due to the following limitations. First, the sample size is small to allow for major generalizations. Second, the subjects' experience in using the communication modes and in performing the social roles may vary and to this effect result in biased responses. Third, pursuing such investigations by means of questionnaires may not be the most appropriate method for evaluating actual use of communication modes. The responses to questionnaires do no reflect user behavior but what users think they do [17]. The conclusions of this study need to be tested more rigorously based on actual behavioral data before the different merits of communication modes against the social roles can be determined. This study should be seen as an attempt to gain insight into how people perceive the value of communication modes against one component of group structure (social roles).

5. References

[1] R.L. Daft and R.H. Lengel, "Organizational Information Requirements, Media Richness, and Structural Design", *Management Science*, 32:5, 1986, pp. 554-571.

[2] R.L. Daft, R.H. Lengel, and L.K. Trevino, "Message Equivocality, Media Selection, and Manager Performance: Implications for Information Systems", *MIS Quarterly*, 11:3, 1987, pp. 355-366.

[3] A.R. Dennis and J.S. Valacich, "Rethinking Media Richness: Towards a Theory of Media Synchronicity", *Proceedings of the 32nd Annual Hawaii International Conference on System Sciences,* Maui, Hawaii, 5 - 8 January, 1999.

[4] C.A. Ellis, S.J. Gibbs, and G.L. Rein "Groupware: Some Issues and Experiences", *Communications of the ACM*, 341, 1991, pp. 38-58.

[5] T. Finholt, L. Sproull, and S. Kiesler "Communication and Performance in Ad Hoc Task Groups", *Intellectual Teamwork: Social and Technological Bases of Cooperative Work*, J. Galegher, R.E. Kraut, and C. Egido (eds.), Lawrence Erlbaum, Inc., Hillsdale, NJ, 1990, pp. 291-325.

[6] R.S. Fish, R.E. Kraut, R.W. Root, and R.E. Rice "Evaluating Video as a Technology for Informal Communication", *CHI '92 Conference Proceedings: Striking a Balance*, P. Bauersfeld, J. Bennett, and G. Lynch (eds.), Addison-Wesley, Monterey, California, May 3-7 1992, pp. 37-48.

[7] Galbraith J., *Strategies of Organizational Design*, Addison-Wesley, Reading, Massachusetts, 1973.

[8] J. Galegher and R.E. Kraut "Computer-Mediated Communication for Intellectual Teamwork: A Field Experiment in Group Writing", *Proceedings of the Conference on Computer-Supported Cooperative Work CSCW '90*, ACM Press, Los Angeles, CA, Oct. 7-10 1990, pp. 65-78.

[9] S. Greenberg, "Personalizable Groupware: Accommodating Individual Roles and Group Differences", *Proceedings of the Second European Conference on Computer-Supported Cooperative Work - ECSCW '91*, L. Bannon, M. Robinson, and K. Schmidt (eds.), Kluwer Academic Publishers, Amsterdam, Sept. 24-27 1991, pp. 17-31.

[10] B.A. Gutek, "Work group structure and information technology: A structural contingency approach", *Intellectual Teamwork: Social Foundations of Cooperative Work*, J. Galegher, R.E. Kraut and C. Egido (eds.), Lawrence Erlbaum Associates, Hillsdale, New Jersey, 1990, pp. 63-78.

[11] N. Kock, (1998), "Can a Leaner Medium Foster Better Group Outcomes? A Study of Computer-Supported Process Improvement Groups", *Effective Utilization and Management of Emerging Information Technologies*, M. Khosrowpour (ed.), Idea Group Publishing, Hershey, PA, 1998, pp. 22-31.

[12] T. Malone and K. Crowston, "What is Coordination Theory and How Can It Help Design Cooperative Work Systems?", *Proceedings of the Conference on Computer-Supported Cooperative Work CSCW'90*, ACM Press, Los Angeles, CA, Oct. 7-10 1990, pp. 357-370.

[13] A. Michailidis, R. Rada, and W. Wang "Matching roles and technology for collaborative work: an empirical assessment", *Wirtschaftsinformatik*, 35:2, 1993, pp. 138-148.

[14] A. Michailidis and R. Rada "A Comparative Study on the Effects of Groupware and Conventional Technologies on the Efficiency of Collaborative Writing", *Computer Supported Cooperative Work,* 3, 1995, pp. 327-357.

[15] A. Michailidis and R. Rada "Collaborative Authoring Tools*", Groupware and Authoring*, R. Rada (ed.), Academic Press, London, 1996, pp. 9-44.

[16] C.M. Neuwirth, D.S. Kaufer, R. Chandhok, and J.H. Morris "Issues in the Design of Computer Support for Co-authoring and Commenting", *Proceedings of the Conference on Computer-Supported Cooperative Work (CSCW '90),* ACM Press, 1990, pp. 183-195.

[17] Nielsen, J., *Usability Engineering*, Academic Press, 1993.

[18] R.B. Ochsman and A. Chapanis "The Effects of 10 Communication Modes on the Behavior of Teams During Co-operative Problem-solving", *International Journal of Man-Machine Studies*, 6, 1974, pp. 579-619.

[19] Platt, S., R. Piepe, and J. Smyth, *Teams: A Game to Develop Group Skills*, Gower, 1988.

[20] Rada, R., *Interactive Media*, Springer-Verlag, New York, 1995.

[21] R. Rada and K. Tochtermann, "Introduction to Expertmedia", Expertmedia: *Expert Systems and Hypermedia*, R. Rada and K. Tochtermann (eds.), World Scientific Publishing, Singapore, 1995, pp. 3-28.

[22] S. Reder and R.G. Schwab "The Communicative Economy of the Workgroup: Multi-Channel Genres of Communication", *Proceedings of the Conference on Computer-Supported Cooperative Work - CSCW88*, Association for Computing Machinery, Portland, Oregon, 1988, pp. 354-368.

[23] W. Reinhard, J. Schweitzer, G. Völksen, and M. Weber, "CSCW Tools: Concepts and Architectures", *Technical Report, paper#930703*, Siemens ZFE, 1993.

[24] M.A. Sasse, M.J. Handley, and S.C. Chuang, "Support for Collaborative Authoring via Email: The MESSIE Environment", *Proceedings of the Third European*

Conference on Computer-Supported Cooperative Work ECSCW '93, G. De Michelis, C. Simone, and K. Schmidt (eds.), Kluwer Academic Publishers, Milan, Italy, 13-17 September 1993, pp. 249-264.

[25] Sproull, L. and S. Kiesler, *Connections: New Ways of Working in the Networked Organization*, MIT Press. 1991.

[26] B.C.Y. Tan, K.K. Wei, C.L. Sia, and K.S. Raman, "A Partial Test of the Task-Medium Fit Proposition in a Group Support System Environment", *ACM Transactions on Computer-Human Interaction*, 6:1, March 1999, pp. 47–66.

[27] E. Williams, "Experimental Comparisons of Face-to-Face and Mediated Communication: A Review", *Psychological Bulletin*, 84:5, 1977, pp. 963-976.