December 2002

A CONCEPTUAL MODEL FOR VIRTUAL COLLABORATION

Gary Baker
University of Northern Iowa

A CONCEPTUAL MODEL FOR VIRTUAL COLLABORATION

Gary Baker
University of Northern Iowa
bakerg@uni.edu

Abstract

Globalization and the changing structures of organizations have created work groups that are distributed across space (different sites) and time. As organizations compete in the Information Age, effective collaboration is often seen as an important factor contributing to the success of individuals, project teams, and organizational growth. Improved connectivity together with the increase in groups and teams has resulted in increased interest in extending the usefulness of IT at the individual level to support the issues faced by virtual teams.

Keywords: Collaborative technologies, virtual teams, decision making, communication media, group cohesiveness.

Introduction

Work teams, collaborative technologies and a highly competitive business environment have contributed to the formation of virtual organizations and virtual teams (Janvanpaa and Ives, 1994; Pasternack and Viscio, 1998). Factors such as privatization, deregulation, and the improvement of transportation and telecommunications have resulted in the emergence of firms where expertise and decision-making are increasingly dispersed throughout the organization. As business strategies evolve and organizational structures change, the use of technology continues to represent an ever-increasing enabler. Redesigned and reengineered information systems provide the infrastructure to support systems integration within and between organizations. Potter et al. (2000) highlight the need to actively manage the distribution of individuals and the collaborative tools within the organization.

Virtual teams consist of geographically dispersed members, who need to collaborate to accomplish ongoing or project-based activities. Effective communication among members is one of the major components of teamwork and is critical to decision-making teams (Keller, 1986; Budman, et al., 1993). The use of collaborative technologies to support communication between geographically dispersed individuals can save companies millions of dollars and contribute to significantly reduced cycle times. While virtual teams remain an emerging and largely unstudied organizational form, companies such as Wells Fargo, Caterpillar, Lockheed, Dow, ARCO and Ford have implemented technology to facilitate the real time interaction of virtual teams (Ferranti, 1997; Burden, 1999).

Collaborative technologies include a wide range of asynchronous and synchronous tools. Asynchronous tools such as email, calendaring systems, and project management systems support coordination activities. Shared work spaces such as group discussion boards and information repositories enable the sharing of knowledge. Finally technologies such as chat rooms, whiteboards, audioconferencing and videoconferencing support virtual synchronous discussions. The use of collaborative technologies continues to grow as their accessibility increases and costs decline. Conference room video systems now cost less than $5000 and generally work over switched circuits (ISDN) to ensure high quality and ease of use. While meeting room and video conferencing applications have been available for years, the availability of these tools for individuals' workstations extends the capabilities of collaborative systems and provides an enormous opportunity to support many different aspects of collaborative work. Newer desktop conferencing provides IP-based systems that plug into USB port and conform to H.323 standards. The Gartner Group (2001) forecasts that by the end of 2003, network-based desktop conferencing will provide a reliably satisfying experience. While feeding audio and video across the Internet may not be practical for today's business meetings, conferencing over a LAN or intranet has a lot to offer. While the functionality of technologies continues to advance and their implementation by organizations increases, there is still much to learn about effective communication and knowledge sharing within virtual teams.

This paper builds on literature from problem solving, group communication and electronic media. The model is developed to provide a basis for studying the impact of different features of collaborative technologies on the effectiveness of virtual teams.

Theoretical Background

As organizations compete in the Information Age, individuals increasingly work with abstract symbols and concepts. No longer can a single individual possess all the information, resources, and experience necessary to understand all the issues and develop implementable solutions to these problems. Organizations have increasingly become a complex network of intertwined processes. Communication and decision making represent the two most common activities performed by groups (Mills, 1967; Fisher, 1974). McGrath and Hollingshead (1994) suggest that at least three different types of factors be considered when evaluating the impact of a given technology on group performance: (1) task performance effectiveness (2) group interaction and performance processes and (3) user reactions to the system and its results.

Traditionally, technology usage has been focused on reducing uncertainty through periodic reporting, or rules and procedures to acquire and analyze information. Effectiveness as measured by use, user satisfaction, or individual impact, has often been used as the measure of information system success. Mason (1978) relabeled effectiveness as "influence" which he describes as a series of events including the receipt of information, the evaluation of the information, and the application of the information, leading to a change in the recipient behavior. Many decisions faced by teams involve situations where limited information is available and individuals must interpret the situation from existing data and negotiate a solution. In studying the behavior of groups meeting in a face-to-face environment, Patton and Griffin (1978) found that the overall attraction of group members to each other and the way in which they "stick together", result in higher levels of cooperation during task performance.

When individuals work as a team to solve a problem or reach a decision, it is possible for them to either compete or cooperate (Jorgeson and Papciak, 1981; Kerr and Kaufman-Gilliland, 1994). Empirical studies comparing collaborative technologies and face-to-face meetings have examined the varying effects on group processes, performance, and user satisfaction. In studying the design and use of collaborative technologies, two of the major areas of concern have been the communication process itself and how technology is used to augment different communication processes. Recently other process-oriented variables such as persuasiveness and consensus have been included when studying the impact of different technologies. The use of different collaborative technologies has been shown to change the dynamics of group interaction by impacting communication patterns, information processing, consensus generation, conflict resolution, and task performance (Turoff and Hiltz, 1982; Kraemer and King, 1988; Zigurs, 1989; McLeod and Likeer, 1992; Hollingshead and McGrath, 1995)

Short, Williams and Christie, (1976) developed a theory of group interaction based on social presence, defined as the degree to which a medium supports the psychological presence of users during an interaction. Social presence includes factors such as sociability, warmth, personalness and sensitivity. In discussing "why do organizations process information?" Daft and Lengel (1986) propose two answers – to reduce uncertainty and reduce equivocality. A recent approach by Dennis et al. (1998) focuses on the ability of different collaborative technology to feedback and concurrency capabilities of different collaborative technologies. Feedback refers to the ability of a medium to provide rapid bi-directional communication and the ease with which the receiver can interrupt the sender. Concurrency refers to the number of simultaneous conversations that can exist effectively in the medium

Conveyance

Conveyance is defined as the imparting or communicating by statement whose "goal is to enable the most rapid exchange of information among participants as possible, and to enable them to effectively process this information and arrive at their individual interpretations of its meaning" (Dennis, et al., 1998, p.52). Organizations are embracing technology to support the increased flow of information such as the routine transfer of data, non-routine interpersonal communication, and project related work between geographically dispersed work groups. While the purpose of many groups is to develop a recommendation for a specific problem or issue, much of the time spent by the individuals is in the exchange of information. This involves not just relating facts and figures but also providing some background and context to understand the many issues involved. Weick and Meader's (1993) sensemaking activities of action, triangulation, and contexualization depend on the exchange of information supported by the conveyance process.

Convergence

Convergence is defined as coming together to unite in a common interest whose "goal is to enable the rapid development of a shared meaning among the participants" (Dennis, et al., 1998, p52). In his work on group problem solving and human behavior, Maier (1952) distinguishes between the quality or adequacy of a solution, and the acceptance and motivation of group members to carry out their decision. Subsequent work by Hoffman (1961) and Hoffman (1964) examined the relationship between the attractiveness of solutions and their adoption by members of the group.

Collaborative technologies differ in their ability to enable team members to develop a common understanding and shared meaning about information. The convergence process of developing a shared meaning among group members can be linked to the affiliation process of comparing views and negotiating shared understanding. For the convergence process, media that focus the communication onto a single issue help in developing a common shared understanding. The sensemaking activity of affirmation can be linked to the convergence process where group members seek to develop and confirm their shared meaning.

Cohesiveness

Members who have a sense of belonging and are dedicated to the well being of the group are more willing to accept influence from the group (Orbell, et al, 1988). In his seminal work of groups Festinger (1950) defines group cohesiveness as "the result of all the forces acting upon the members to remain in the group". Interpersonal communication can be viewed as the organizing element for individuals in a group and has been shown to be one of the most important means for gaining the commitment to the task and to the group itself (Kerr and Kaufman-Gilliland, 1994). The essence of teams, either virtual or face-to-face, is that collections of individuals have relationships that make them interdependent to some significant degree. This state of inter-dependence can be regarded as cohesion.

In describing the positive effects of cohesiveness on team members Cartwright and Zander (1968) state "The improved interpersonal relations involved in an increase in cohesiveness lead to more acceptance, trust, and confidence among members and … each member consequently develops a sense of security and personal worth" (p. 104). The interpersonal attraction, commitment to task, and group pride dimensions of cohesiveness can be seen to influence members to view the group as "we" and take a more active role in the group's work. Various studies have reported the general conclusion that cohesiveness leads to increased social influence which in most cases produces greater conformity to group standards. Several studies have shown a positive relationship between cohesiveness and a number of positive outcomes such as higher motivation, greater creativity, and better decisions (Keller, 1986; Budman, et al., 1993).

Conceptual Model

When groups engage in problem solving, they engage in a variety of activities. Hackman and Morris (1975) developed a model which focuses on the process-performance relationship of group performance. Their model suggests that group process affects task performance through three *summary* variables: member's efforts, task performance strategies and member skill and knowledge. Successful collaboration requires not only that team members convey their ideas, but also that members converge to a common shared understanding of the issues and develop a commitment to the group's decision.

In describing the coordination problems associated with decision-making, Ackoff (1981) highlighted the importance of understanding how and why a decision is made. As collaborative systems have evolved, they provide multiple features to support the communication and group processes of virtual teams. The model presented here (see Figure 1) focuses on the task performance as an outcome from three intervening constructs, conveyance, and cohesiveness together with a feedback loop to reflect the impact of previous group tasks.

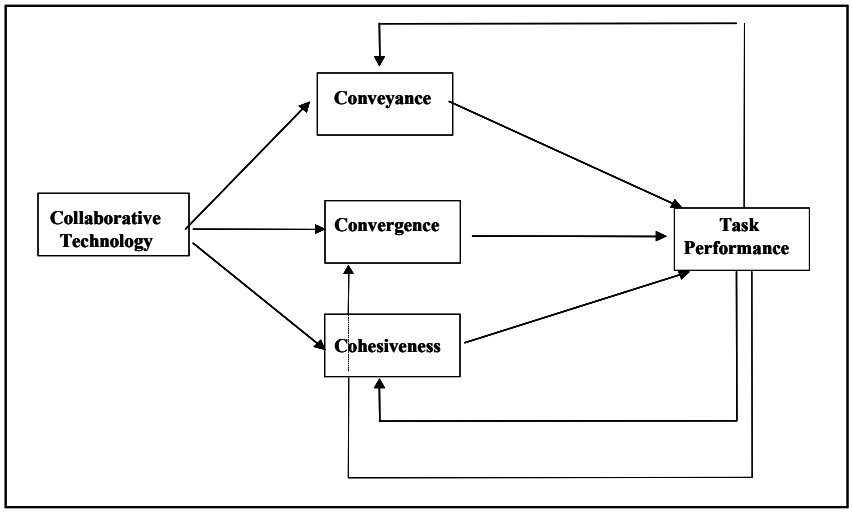

Figure 1. Conceptual Model for Collaborative Technology

As problem solving and decision making groups move from face-to-face to virtual environments it is important to re-examine factors that have been shown as important for task performance in face-to-face teams. Members in a decision-making group resolve problems by focusing on particular issues and attempting to develop a common understanding. The primary concern of this research is the effect of specific attributes of collaborative technologies. The model posits that the specific features of collaborative technologies will affect the conveyance of information, convergence to a shared understanding, and cohesiveness of the team members. The model posits three major propositions. The first of these major propositions posits that:

> **Proposition 1A:** *Collaborative technologies which provide concurrent communication channels result in a higher conveyance of information.*
>
> **Proposition 1B:** *Collaborative technologies which provide a focus on the development of a common understanding result in a higher level of convergence of shared information.*
>
> **Proposition 1C:** *Collaborative technologies which provide multiple communication channels result in a higher level of cohesiveness.*

Successful performance of the task requires not only that group members convey their ideas and understanding, but also that members develop a common shared understanding of the issues. One of the underlying premises in the cohesiveness-performance relationship is that increased cohesiveness leads to increased cooperation and that increased cooperation leads to increased performance. While conformity has some potentially undesirable outcomes, there are many compelling positive outcomes associated with conformity. The successful task performance resulting from collaborative process has been shown to depend on the extent to which the " conveyance and convergence" result in a commitment by the group members (Orbell, Dawes and van de Kragt, 1990; Kerr, 1992). Thus the second proposition is:

> **Proposition 2:** *Higher levels of conveyance, convergence and cohesiveness have a positive impact on task performance.*

Communication is one form of behavior that represents both a consequence of proceeding contingencies and a determinant of future interaction within the group. Mullen and Copper (1994) suggest that the most direct effect might be from performance to cohesiveness rather than from cohesiveness to performance. Perceptions of the process and previous attitudes are associated with the dynamic nature of groups. Positive performance has been shown to improve subsequent performance. Thus the third proposition is:

> **Proposition 3:** *Task performance has a positive impact on subsequent conveyance, convergence and group cohesiveness.*

Research Methodology

In studying the different aspects of communication and behavior between individuals, social psychologists have often used the Prisoner's Dilemma Game. The resource dilemma problem used in this study was a group version of this game in which members must decide between their own self-interest and the overall interest of the group. Data has been collected from 64 teams utilizing White Plain's CU-SeeMe software. Teams consisted of 3 to 4 individuals who had worked together on two prior projects. For purposes of consistency, the virtual meetings were held in a lab setting with separate identically configured "breakout" rooms. All of the rooms contained identically configured computers and were connected using a 100MB Ethernet network. Videum © cameras with capture boards and headsets with attached microphones were installed to support audio and video communication channels. Setting for each of the different conditions, text-only, audio-only, text-video and audio-video were randomly assigned and the systems reconfigured prior to each team's scheduled meeting. Specific features of the software not utilized by a group were hidden from view and disabled from the software. In all conditions, the team members communicated freely with no major disruptions. Video quality was generally good during the sessions. Audio quality was more variable, due to the system's ability to only broadcast a single audio speaker thereby requiring turn taking during discussions. The discussions of the audio-based groups were captured using separate recording devices and transcribed into text documents. The discussions of the text-based groups were captured via the software.

Preliminary Findings

The preliminary results from the study were generally in the predicted direction across the different collaborative technologies, see Table 1. Text-only communication (high in conveyance but is low to medium in supporting convergence) resulted in better task performance (1028 versus 724) than audio-only communication (low in conveyance but is medium in supporting convergence). The addition of video to audio-only communication, which maintains the low level of concurrency and increases the convergence, resulted in significantly better task performance (1396 versus 724). The addition of video to the text-only communication, which maintains the high level of concurrency and increases the convergence, resulted in slightly worse task performance (991 versus 1028). These preliminary results of the study show that for the task used in the study, the addition of video to audio-based communication results in improved decisions by virtual teams. Other factors in the research model include the effect of collaborative technologies on cohesiveness which will be analyzed together with the impact of cohesiveness on task performance. Finally the feedback loop will be analyzed to assess the impact of task performance on subsequent conveyance, convergence and group cohesiveness measures.

As problem solving and decision-making groups move from face-to-face to virtual environments it is important to re-examine the use of collaborative technologies. With the increasing availability of videoconferencing, a July 2001 Wainhouse Research study shows that organizations continue to assess the widespread deployment on a "cost justification" basis which can be interpreted as "*do we really need video*?" As the organizational importance of virtual teams and their use of collaborative technologies increases, it is necessary to understand how these technologies affect the ways in which individuals interact. As problem solving and decision making groups move from face-to-face to virtual environments it is important to re-examine group process characteristics such as the participation level of group members, degree of cooperation and the domination of group processes by members together with interpersonal characteristics such as the cohesiveness, satisfaction with the process and satisfaction with the outcome. These factors will help to provide a more complete understanding of how the media characteristics of concurrency and feedback impact the underlying communication processes of conveyance and convergence for virtual teams.

Table 1. Task Performance by Collaborative Technology

	Text	Audio
No Video		
Mean	1028	724
Standard Deviation	(751)	(638)
Video		
Mean	991	1396
Standard Deviation	(715)	(631)

References

Ackoff, R.L. *Creating the Corporate Future: Plan or Be Planned for*, John Wiley & Sons, New York, 1981

Budman, S.H., Soldz, S., Demby, A., Davis, M. and Merry, J. "What is cohesiveness? An empirical examination," *Small Group Research*, (24: 2), May 1993, pp. 199-216.

Cartwright, D. and Zander, A. *Group Dynamics: Research and Theory*, Harper & Row, New York, 1968.

Daft, R. and Lengel, R. "Organizational information requirements, media richness, and structure design," *Management Science*, (32: 5), May 1986, pp. 554-571.

Dennis, A.R., Valacich, J.S., Speier, C. and Morris, M.G. "Beyond media richness: An empirical test of media synchronicity theory," *Proceedings of 1998 Annual Hawaii International Conference on Systems Science,* Maui, January 1998, pp. 48-57.

Ferranti, M. "Automaker aims for company-wide collaborative standards," *Computing*, December 11, 1997.

Festinger, L. "Informal social communication," *Psychological Review*, (57: 5), September 1950, pp. 271-282.

Fisher, B.A. *Small Group Decision Making: Communication and the Group Process*, McGraw-Hill Book Company, New York, 1974.

Gartner Group "Videoconferencing can help enterprises cut travel," *Gartner Group Research Note*, October 9, 2001

Hackman, J.R. and Morris, C.G. "Group task, group interaction process, and group performance effectiveness: A review and proposed integration", in *Advances in Experimental Social Psychology* (Vol. 9*)*, L. Berkowitz (ed.), Academic Press, New York, 1975),pp.47-99.

Hoffman, L.R. "Conditions for creative problem solving," *Journal of Psychology*, (52: 2), October 1961, pp. 429-444.

Hoffman, L.R. "Valance in the adoption of solutions by problem solving groups: Concept method, and results," *Journal of Abnormal and Social Psychology*, (69: 3), September 1964, pp. 264-271.

Hollingshead, A.B. and McGrath, J.E. "Computer-assisted groups: A critical review of the empirical research", in *Team Decision and Team Performance in Organizations*, R. A. Guzzo and. E. Salas (eds.), Jossey-Bass, San Francisco, CA, 1995, pp. 46-78.

Jarvenpaa, S. and Ives, B. "The global network organization of the future: information management opportunities and challenges", *Journal of Management Information Systems*, 1994 10, pp. 25-57.

Jorgeson, D.O. and Papciak, A.S. "The effects of communication, resource feedback, and identifiability on behavior in a simulated commons," *Journal of Experimental Social Psychology*, (17: 4), July 1981, pp. 373-385.

Keller, R.T. "Predictors of the performance of project groups in R&D organizations," *Academy of Management Journal*, (29: 4), December 1986, pp. 715-726.

Kerr, N.L. and Kaufman-Gilliland, C.M. "Communication, commitment, and cooperation in social dilemmas," *Journal of Personality and Social Psychology*, (66: 3), March 1994, pp. 513-529.

Kerr, N.L. "Efficacy as a causal and moderating variable in social dilemmas", in *Social Dilemmas: Theoretical Issues and Research Findings*, D. M. W. Librand, & H. Wilke (eds.), Pergamon Press, New York, 1992, pp. 59-80.

Kraemer, K. and King, J. "Computer-based systems for cooperative work and decision making," *ACM Computing Surveys*, (20: 2), June 1988, pp. 115-146.

Mason, R.O. "Measuring information output: A communication systems approach," *Information & Management*, (1: 5), October 1978, pp. 219-234.

Maier, N.R.F. *Principles of Human Relations*, John Wiley, NewYork, 1952.

McGrath, J.E. and Hollingshead, A.B. *Groups Interacting With Technology*, Sage Publications, Thousand Oaks, CA, 1994.

McLeod, P.L. and Likeer, J.K. "Electronic meeting systems: Evidence from a low structure environment," *Information Systems Research*, (3: 3), September 1992, pp. 195-223.

Mills, T.M. *The Sociology of Small Groups*, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1967.

Mullen, B. and Copper, C. "The relation between group cohesiveness and performance: An integration," *Psychological Bulletin*, (115: 2), March 1994, pp. 210-227.

Orbell, J.M., van de Kragt, A.J. and Dawes, R.M. "Explaining discussion-induced cooperation," *Journal of Personality and Social Psychology*, (54,5), May 1988, pp.811-819

Pasternack, B. and Visco, A. *The centerless corporation*, Simon and Schuster, New York, 1998.

Patton, B.R. and Giffin, K. *Decision-Making Group Interaction*, Harper & Row, New York, 1978.

Potter, R.E., Balthazard, R.A, and Cooke, R.A. "Virtual ream interaction: assessment, consequences, and management, *Team Performance Management: An International Journal, (*6:7/8), 2000, pp. 131-137.

Short, J.E., Williams, E. and Christie, B. *The Social Psychology of Communications*, John Wiley, London, 1976.

Turoff, M. and Hiltz, S.R. "Computer support for group versus individual decisions," *IEEE Transactions on Communications*, (Com-30: 1), January 1982, pp. 82-90.

Wainhouse Research "Videoconferencing and visual collaboration endpoints deployment and plans," *Endpoint Survey*, July 2001.

Weick, K.E. and Meader, D.K. "Sensemaking and group support systems", in *Group Support Systems: New Perspectives*, L. M. Jessup and J. S. Valacich (eds.), Macmillan Publishing, New York, 1993, pp. 230-252.

Zigurs, I. "Interaction analysis in GDSS research: Description of an experience and some recommendations," *Decision Support Systems*, (5: 2), June 1989, pp. 233-241.