Computer-Mediated Communication and Shared Learning

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Abstract: Despite decades of development, user-friendliness still presents a constraint on the diffusion of computer-mediated communication (CMC). Research indicates that CMC systems are generally not capable of structuring interaction to a degree appropriate for goal-directed behaviour. thus limiting their usefulness in collaborative work or teaching. This paper reviews a variety of techniques which have been developed to get groups of people to communicate effectively: cooperatlve learning. team building, groupware, computersupported cooperatlve work, decision support systems, and organizational design. Some of these approaches have achieved modest success in moderating computer exchanges-for example, in using AI to direct interaction. However. this paper suggests that future research could be productively guided by the growing literature on "shared learning": the concept that organizations can be designed in such a way that they "learn" from past experience. Recent research on this outgrowth of the application of "learning curves" in production engineering is used to suggest ways in which AI mlght be used to improve the utility of CMC.

Resume: En dépit desannées de développement, la convivialite continue de limiter la diffusion des systèmes de communication assistés par ordlnateur. La recherche indique que ces systemes ne donnent pas à l'interaction unestructuresuffisante pour supporter la collaborationsur les buts communs -comme, par exemple — à l'apprentissage, ou au travail cooperatif. Cet article présente quelques techniques qu'on a utilisées jusqu'à ici pour promouvoir la communication dans les groupes: apprentissage cooperative travail en groupes, 'groupware,' 'CSCW," 'decislon support systems." "organizatlonal deslgn." Bien que ces techniques ont produit des résultats modestes, on suggère ici que la recherche doit être guider par la literature crossainte sur "shared learning" : l'idée qu'on peut dessiner les organkations tel qu'elles aprennent de leur expérience collective. Selon l'auteur, les concepts de "shared learning' peuvent informer l'application de IA pour améliorer les systemes de communication assistes par ordinateur,

Recent research on "computer-mediated communications" continues to draw attention to the problem of making these systems more user-friendly. As Melone points out, user-satisfaction has been examined for nearly two decades, directly, or indirectly as an indicator of system effectiveness (Melone, 1990). Clearly, if users do not feel comfortable with the technology, or do not accept it as a substitute for more established forms of interaction, computer mediated communication may remain a fringe activity. While technical aspects ofsystem quality cannot be ignored, the more difficult challenge is to satisfy users' socio-emotive needs.

These concerns echo those expressed two decades ago over teleconfer-encing, concerns which generated a vast body of literature. Not surprisingly, current conclusions are starting to resemble earlier ones: for example, that users are happier with mediated communications when they already know the people at the other end, and can work on a common task (Hiltz & Johnson, 1990; cp. Hough & Panko, 1977, Ch. VII and pp.176-178).

A new twist is that the inability of mediated communications to replicate face-to-face interaction is now seen as an advantage rather than a significant failure. Since computers do not transmit the non-verbal cues associated with status, coercion, and so on, it is argued that they remove constraints on a free exchange of ideas (Boyd, 1989). This may be true; but at what point does free-for-all become chaos? Communicating by computer can produce very boring exchanges, reflecting a lack of direction and resolution (Keisler, Siegel & McGuire, 1984; Mason, 1987). While a "level playing field" might occasionally allow revolutionary ideas to surface from unexpected corners, most of the time communication can only procede when the participants share some beliefs, values, and sense of purpose. This is particularly important when communication has an identified goal, such as learning, or working on a common task. Indeed, Boyd quickly adds that even the most democratic exchanges between individuals depend upon a set of rules. And the rules will probably have to be clearer and stronger if the exchanges are to be collaborative and goal directed.

Giving some direction to mediated communication means achieving a delicate balance: no control tends to produce unsatisfying, unproductive interaction; strict control tends to stultify it (Keisler, Siegel & McGuire, 1984, p.1130). Belief that this delicate balance can be attained has stimulated a number of different and heretofore unrelated lines of research. Each is based on the assumption that there is some way of helping groups of people to communicate more effectively

Cooperative Learning

Some of the earliest academic efforts at coordinating the activities of groups of people arose in the context of "cooperative learning." Dewey and Piaget saw interaction with peers playing a key part in expanding cognitive experience (Abrami et al., 1990, p.22). In recent attempts to balance the excessive emphasis on the individual in twentieth century psychology, researchers have begun to explore the benefits of learning in groups. There is some evidence that learning in a cooperative environment, rather than in isolation, improves attitudes, raises the level of achievement, and is more efficient. These benefits may be greatest in more open-ended activities, for learning in groups appears to generate more divergent thinking and more creative problem solvingbehaviour. Similar advantages have been found when cooperation is effected by linking individuals via computers (see literature review by Johnson Johnson, 1989).

These studies have made an important contribution to what we know about the conditions favouring cooperative effort. Two key factors are feedback and accountability. Feedback includes overt rewards, which seem to have the greatest impact on learning when they are based on group rather than individual performance. It also includes the more covert support provided as the participants discuss, explain and elaborate the learning process. For these effects to occur, it seems necessary that each group member understand the collective goal, have some role in the common activity, and feel accountable for it (see review by Slavin, 1989).

Groups thus seem to work well together when their members depend on one another. Interdepence can be encouraged by common goals, rewards, resources, tasks, roles and threats (Abrami et al., 1990). It seems obvious that interdependence will be established more readily if the group members are more "compatible" in some sense. One dimension of compatibility which has been explored in this context is intellectual ability. Groups composed of individuals of similar ability do not necessarily perform well. Generally, groups appear to perform better when their members have something to learn from one another (Nicholson, 1991).

Team Building

Group members appear to learn most from one another when they share symbol systems, and when there is an optimal overlap of their abilities and roles, in industrial (Cohen & Levinthal, 1990, pp. 133-34) as wellaseducational contexts. This type of evidence has led to the development of a number of strategies for building and strengthening teamwork. Broadly speaking, these strategies address three different facets of team building: selecting team members who will work well together; providing training and practice in cooperative behaviour for established teams; and creating conditions (such as reward structure, better communications) to facilitate cooperation in day-to-day activities.

Obviously, the selection strategy is limited to the rare situations where new working groups are being formed. Though innovative methods of organizing work are starting to gain credibility in North America, existing practice tends to restrict the freedom of managers to re-organize the workforce. Similarly, the training approach is limited to situations where the group membership is known in advance, and the members have the time and inclination to participate in planned learning programs. This might be the case in industrial settings where strategy entails cooperation between circumscribed units, such as Marketing and Manufacturing. However, even in such settings, the actual pattern of communications may not follow the theoretical plan prescribed by corporate structure; the key communications may in fact be spontaneous and unofficial. In this case, and certainly in the case of electronic mail or groupware systems, the only alternative available is to provide the conditions which will make spontaneous communications more cooperative and effective. One way of doing this is to facilitate communication by means of a networkof electronic tools: Groupware or Decision Support Systems. Another is to manipulate the factors which contribute to good Organizational Design. Relevant research in these domains is treated in the following sections.

Groupware / Cooperative Work

One approach to group communications has grown out of the practical need to make effective use of networked computing systems. Formalized as "Computer Supported Cooperative Work" (CSCW), this approach has focussed on the development of electronic tools to facilitate collaboration within offices, or across offices dispersed in space or time. These tools encompass collaborative dialogue; document development, production and control; shared research resources, such as libraries, dictionaries, and information on procedures and techniques; project management; and computer-based instruction. They might be embodied in a dedicated environment, such as the special input and output consoles and software of Stanford's "Augmentation Research Center" (Engelbart & Lehtman, 1988); or in portable "groupware" (Opper, 1988) designed to be used on any suitable network, especially PC LAN's. Obviously, groupware has a greater potential for widespread use than dedicated hardware.

Current groupware can at best provide "passive" coordination of individuals using the same electronic medium towards some common end. In other words, groupware supplies the tools (eg. file sharing, agenda setting, etc.), typically with an Artificial Intelligence component, which the users can choose to employ to coordinate their activities (e.g., writing a common document, setting up a meeting). ***Information Lens*** from MIT helps users filter, sort, and set priorities for messages arriving via electronic mail. To do this, its AI component casts these messages into "frames"and uses rules to organize them (Crowston and Malone, 1988). Given the limited power of current natural language parsers, this approach does not achieve any greater coordination of communication than the application of memo forms in the paper domain. There seems to be very little progress on the much more difficult task of building "active" coordination into the technology.

Other experimental forms of groupware seem to be headed in this direction. For example, ***SuperSync*** attempts to facilitate group interaction by predicting how pairs of individuals will get along. It gathers answers to questions like 'You will most probably obtain the best advice from whom?" to draw up "sociograms" which can be used to select groups which will function effectively However, Supersync does not have any of the communication-facilitating functions one expects in groupware (Opper, 1988). Here again, AI is used for "passive" coordination, since it is applied before the group members begin to interact.

Groupware will only advance to "active coordination," or real communication-management, when its AI functions take into account some of the results of other approaches to group interaction.

Decision Support Systems

One of these other approaches is the design of Decision Support Systems which are intended to improve decision-making by providing electronic access to databases, analytic and statistical tools, modelling techniques and so on. This technology is becoming much more important with the growing use of Management Information Systems, which will tend to decentralize not only access to information that is critical to an organization's operations, but also the ability to change this information and act on it. Optimizing the operations of these systems is obviously crucial to corporate survival.

Decision-making is very much a directed behaviour, with a limited set of goals and means available. Much of the early literature focussed on highly rational models of decision-making, such as expectancy theory, involving the weighing of probabilities ofvarious events and outcomes. More recent research (Mitchell & Beach, 1990, p.2) indicates that most business decisions involve choosing whether or not to pursue one available course of action (rather than a choice among competing options); and that the criteria tend to be qualitative (sustaining the organization's strategy) rather than quantitative (profit maximizing).

Another trend has been to consider decision-making as a group behaviour rather than the act of the isolated executive. This is consistent with the decentralizing tendency of MIS and with the fact that decisions increasingly involve the assessment of large amounts of quantitative and qualitative information, as noted above.

A third trend is to try to transplant to computer conferencing methods of structuring communication which have been developed for decision-making in face-to-face situations. A good example of this is Archer's development of the Computer Conferencing Nominal Asynchronous approach, which attempts to balance creativity and control. Creativity is encouraged by the Nominal Group technique for eliciting responses from all participants. Control is imposed by filtering contributions through a moderator (Archer, 1989).

Not surprisingly, these trends have come together in work on Group Decision Support Systems, which allow several users simultaneous access to the relevant information and analytic tools. In what is probably the most advanced form of this technology to date, the PLEXSYS Planning System, up to 4 dozen people can be linked electronically to one another and to an elaborate collection of databases, statistical tools and analytic models (Nunaker, et al, 1988). PLEXSYS uses a combination of knowledge representation techniques and semantic inheritance networks to direct the use of these planning tools. On-screen "frames" are used to reduce the vast complexity of databases and analytic processes available to manageable steps, allowing the user to construct concepts and query the system in an interactive fashion.

Tests of PLEXSYS with 40 brain-storming groups confirm some findings in the computer-communications literature and contradict others. As in other studies, the anonymity of mediated messaging encouraged participation and minimized "group think."It also tended to increase tension by allowingblunter comments and prolonging misunderstandings. In contrast, groups using PLEXSYS generated more comments than those meeting face-to-face; and they expressed more satisfaction with their sessions and more confidence in their outcomes than typical computer-conferees. Nunaker and colleagues attributed the superior performance of PLEXSYS to the facts that they used real decision makers dealing with real problems; that they used larger groups (optimally, 8-22 people, rather than 2-5); and that the hardware and software had been "matured" by eight years of development.

In spite of its relative success, PLEXSYS has two significant limitations as a prototype for directive systems of mediated-communication. First, it is obviously a dedicated rather than portable system, with conference facilities, supporting hardware, and software for up to 48 people. Secondly, use of the system provides for face-to-face meetings whenever desired. Indeed, the physical facilities include rooms for face-to-face meetings, and never really isolate the users from one another. Nunaker et al. attribute some of the success of PLEXSYS to the opportunities to use face-to-face meetings for resolving misunderstandings, and so on.

Consequently, PLEXSYS is perhaps best considered an idealized model, a simulation of what might be achieved, rather than production prototype. Its electronic hardware can be emulated by more diffuse networks. Its software imposes a "frame" approach on brain-storming, a rather open-ended task. The claims that it is very user-friendly and successful need to be examined further. Most importantly, the role of face-to-face communication in this success needs to be investigated carefully, as this finding tends to confirm the suggestion, from research over two decades, that mediated commmunication by itself cannot fill all needs for interaction.

Organizational Design

Hiltz and Johnson have concluded that computer-mediated communication will be more successful in an environment which has at least some structure, tailored to the nature of the group of users (Hiltz &Johnson, 1990). 'lb add some substance to their conclusion, they refer to the work of Daft and Engel on organizational design, work that is interesting for two reasons.

First, Daft and Engel examine the design of organizations in terms of their ability to process information @aft & Engel, 1986). Organizations exist to reduce uncertainty and equivocality in their operating environments. Drawingon previous research (e.g., Daft & Weick, 1984; Tushman and Nadler, 1977), they isolate a number of binary variables which describe the nature of operating environments, types of information required to master them, types of organization and types of business strategy. They combine these variables in a series of 2x2 matrices to create a model of organizational design. Figure 1 (see following page) summarizes the model.

The premise of this model is that organizations process information in order to deal with uncertainty (lack of data) and equivocality (ambiguous data). In general terms, the model proposes that organizations deal with these problems in different ways, depending on the degree to which tasks are variable, and analysable; and on the degree to which corporate departments are functionally different and interdependent. Organizations can respond to these types of situations by varying the amount and the richness of information that is exchanged among departments. In practice, this means tinkering with the "structural mechanisms" and technologies which coordinate and control the organization's internal and external communication, drawing appropriately from a range of different communications modes. Daft and model

Figure 1.
*A Summary of Daft and Engel's Model of Organizational Design**

EQUIVOCALITY	UNCERTAINTY: LOW	UNCERTAINTY: HIGH
HIGH	*Craft Technology* unanalysable environment low task variety differentiated departments low interdependence	*Nonroutine Technology* unanalysable environment high task variety differentiated departments high interdependence
	rich media low information flow (occasional face-to-face, telephone	rich media high information flow (frequent face-to-face, special reports)
LOW	*Routine Technology* analysable environment low task variety undifferentiated departments low interdependence	*Engineering Technology* analysable environment high task variety undifferentiated departments high interdependence
	thin media low information flow (formal rules, bulletins)	thin media high information flow (data bases, MIS, formal plans)

*Their model is greatly simplified here by collapsing four 2x2 matrices (see Daft & Engel, 1986). The larger boxes indicate communications environments; the smaller ones indicate communications modes.

gives general advice on how to carry out such tinkering, but they suggest that their real contribution is to point out that the main problem is not lack of information, but the ambiguity of that which is available. The next section provides an example of the application of this model to an actual situation.

Shared Learning

A second reason that Daft and Engel's work is interesting is that it provides a link to another approach to organizational design: the work on learning curves. Originating in industrial engineering, this large body of literature deals with the observation that the performance of production units in manufacturing tends to improve with time, generally following the shape of the classical learning curve. Until recently, the research has focussed postfacto on the shape of the curve, rather than on the factors which might affect its shape, or the question of how learning occurs, if at all.

In a paper on what he calls "shared learning, "Adler uses Daft and Engel's uncertainty/equivocality matrix to try to explain, in terms of information flows, how an organization improves its performance over time and space (Adler, 1990). This is a case-study of the evolution of the design and manufacture of a high-tech product, in which a firm has detected and remedied problems with the flow of critical information among its functional units. Improvements mainly involved changing who talked to whom, what about and when. In Adler's terms, these improvements were based upon a clearer perception of the differentiation and interdependence among the functional units. For example, the firm created "centres of competence" to recognize and reinforce creativity at branch plants, with rich internal communications but restricted links with other units On the other hand, the firm reacted to the interdependence of design and manufacturing functions by increasing the richness and volume of communication between the formal units.

Broadly speaking, the firm had to replace some of its formal rules, which defined its structure in hierarchical terms, with more informal guidelines prescribing a timely flow of information. This was accomplished not by changing telecommunications links but by physically moving people: by setting up new sub-units for liaison, by creating new "'start-up" teams, and by job rotation. These types of practice are already well established in Japanese firms, which have evolved into what can be called "learning machines" (Dicks, 1986). Adler's contribution is to link the cognitive and structural aspects of corporate learning within an analytic framework which might be generalizable to any group of people with common goals.

In another empirical study, Cohen and Levinthal investigate the capacity of organization to learn. "Absortive capacity" they define as ".. .the ability of a firm to recognize the value of new, external information, assimilate it and apply it to commercial ends..." (Cohen & Levinthal, 1990). A key finding is that corporate learning depends upon a firm having an adequate technological base, and a workforce capable of developing it. In their terms, this means that members of the workforce should possess a balanced mixture of shared and unique abilities; and they should be intimately familiar with the formal and informal communications channels which underly the firm's operations (pp. **148; 133-135).**

Design Of Computer-Mediated Communications Systems

Returning to the perceived need for imposing more strucure on computer-mediated communications (Boyd, 1989, Hiltz & Johnson, 1990), we can learn a little from this diverse body of research on group interaction. For one thing, there is further reinforcement for the old finding that face-to-face interaction fulfils a crucial role in successful communication, in establishing an initial foundation of trust and in resolving misunderstandings. It is nonetheless conceivable that future mediation systems will sufficiently replicate face-to-face conditions so that people will not have to meet in real space and time.

The work of Daft and Engel at least provides a starting point for deciding under what conditions "thin" communications media, such as asynchronous electronic mail, aresufficient; and what conditions "rich" media, such as broad-band data supplemented by live video and high quality sound, are necessary, The model sketched in Figure 1 may be useful when one has the time to design the relationships between parts of an formal organization, such as a business firm or government bureau. In these cases, the rewards and sanctions required to get the system working are also at hand. However, these tools may not be available when one is designing the links between parts of a research consortium or a university, organizations which are expected to be less formal, less predictable. In these latter cases, effective communication is perhaps even more important, but it is difficult to see how Daft and Engel's criteria can be applied to spontaneously arising interactions- unless by a clever application of Artificial Intelligence!

As we have seen above, AI has been applied in rather limited ways to keeping track of what users are communicating about, or deciding 'a priori'how well team members will get along. Using AI to decide who should communicate with whom, when, and by what combination of media would probably be more productive, and certainly more of a challenge. An AI system in this case would have to develop profiles of communicators, based on their communications environment in Daft and Engel's terms, their role in the goal-seeking activity their repertoireofskills and knowledge. Perhaps such a system would also take a less mechanistic approach (see Mitchell & Beach, 1990) and so include their vocabulary of images as well. AI would thus serve as a real-time mediator perhaps only in an advisory role, recommending when communications should occur, in what direction, and by what types of channels.

In designing such a system, we might want to start with three general attributes (Silver, 1988; in his case, for DSS systems). These are *Restrictiveness, Guidance and Focus.* Restrictiveness refers to the fact that a communications system, particularly one which is to serve goal-directed behavior, must reflect some choices among all possible alternatives. As a simple example, access must be restricted to a useful subset of all possible communicators. Further, only some members of this subset might be allowed to access certain data; or to perform certain kinds of operations, such as modelling. Guidance refers to help the system may provide its users in taking the next step: who to communicate with, which information to consult in making a decision, and so on. Focus refers to the degree to which a system is tailored to a specific use. For example, an MIS is highly focussed, since certain people have certain types of access, and their communications must maintain a high degree of precision. Similarly, a system designed to allow researchers to communicate about a particular problem might be highly focussed, with features designed to facilitate certain tasks but not others. On the other hand, a brain-storming system might have a very loose design. As a rule, the greater a system's focus, the more restrictive it will be and the less the need for guidance; and conversely, an unfocussed system will present more alternatives for action, and hence should provide more guidance for its users.

The real challenge is to create a mediating system which can respond to varying communications scenarios with an appropriate balance of these attributes. In the literature, there is enough knowledge about the conditions which promote effective cooperation, and about how to measure them, to begin facing this challenge. We know that interdependence is a key factor in the effective functioning of groups, and that Daft and Engel's model gives us some way of dealing with this variable. We also know that an appropriate balance of shared and unique abilities is a key factor. Finally, we know that effective organizations exhibit a balance of what has been called "loose" and "tight" coupling (Cameron, 1986; Weick, 1976). This might best be explained in an example: an effective organization should have the creativity and flexibilty created by "loose coupling" among its units in order to envision new business opportunities; and, at the same time, enough "tight coupling" in order to build new production facilities and pay the bills on time.

In Cameron's terms, an appropriate balance of loose and tight coupling is one of the key paradoxes which characterize effective organizations. Tolerating the co-existence of opposites is a necessary feature of working in groups. Further, "paradoxes are paradoxical" : empirical evidence indicates highly effective organizations (at least in higher education) can perform ". . .in contradictory ways to satisfy contradictory expectations." (Cameron, 1986). This suggests that an AI system for mediating computer-mediated communications in such a way as to promote group learning will have to embody enough fuzziness to live with and perhaps even promote these paradoxes.

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