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ASYNCHRONOUS GROUPWARE SUPPORT EFFECTS ON PROCESS IMPROVEMENT GROUPS: AN ACTION RESEARCH STUDY

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Abstract

We report on a study of seven process improvement groups in two New Zealand organizations. All groups followed the same group methodology and were facilitated by the researcher. The research approach used was action research. All groups interacted with the support of an e-mail conferencing tool. Six of the groups used e-mail conferencing as the main medium of interaction, and their members interacted through the e-mail conferencing system during 67 to 89 percent of the time. One of the groups conducted most of the discussion through a face-to-face meeting, using e-mail conferencing during only 18 percent of the time. Five of the groups were successful in generating and either fully or partially implementing process redesign proposals. Two of the groups failed to generate any process redesign proposal. Research data was collected through participant observation, unstructured and structured interviews, and in the form of e-mail discussion transcripts. This research data indicates that, while not having negative perceived effects on group effectiveness, asynchronous groupware support was perceived as increasing process adoption, hierarchy suppression, departmental heterogeneity, and contribution length, and decreasing discussion duration, cost, and interaction in process improvement groups.

1. INTRODUCTION

The concept of business process has been the basis of several organizational development movements, in particular the total quality management (TQM) and the business process re-engineering (BPR) movements, whose peaks of worldwide attention occurred respectively in the 1980s and 1990s. In addition to their focus on business processes, these movements also share some other characteristics. Among these characteristics is one of particular interest in this study, which is their reliance on small groups, i.e., with three to fifteen members, with well defined member roles to generate and coordinate the implementation of process improvement proposals (Deming 1986; Ishikawa 1986; Walton 1991; Hammer and Champy 1993; Soles 1994). We refer to these small groups in this paper as process improvement (PI) groups.

The general literature on empirical studies of groupware support for groups widely acknowledges some effects that indicate potential benefits of its use as a tool for PI groups. Among these effects are better support for group activities and positive effects on individual and group behavior. For example, Sproull and Kiesler (1991) argue that communication becomes faster and cheaper and that individuals communicate more openly; Wilson (1991) points out that paper flow in organizations is reduced; Brothers et al. (1992) argue that group discussion data is recorded in a more efficient way; Clement (1994) argues that cross-departmental communication is increased; Nunamaker et al. (1991) show that individual contributions are better distributed in group discussions; Chidambaram and Kautz (1993) argue that ideas are separated from individuals and are thus considered on their own merit; and Sheffield and Gallupe (1993) show that the repetition of old ideas in meetings is reduced and that commitment toward group decisions is increased. Most of these examples analyzed the impact of asynchronous (e.g., e-mail) and synchronous groupware (e.g., GDSS) in comparison to similar face-to-face situations.

In spite of the potentially positive effects that groupware may have on PI groups, related empirical research has been limited. There have been some representative examples of research studies where groupware was used to support PI groups, such as Pietro's (1992) study of quality improvement groups, the Dennis et al. (1993) study of one business process re-engineering group, and the Dennis, Hayes and Daniels (1994) study of business process modeling groups. These studies, however, have focused on synchronous groupware tools, particularly GDSSs. This focus is curious since these systems have had a very modest

commercial success when compared with some instances of asynchronous groupware systems, such as e-mail, and are thus less likely to be found in organizations (Grudin 1994). In consequence, one could quite reasonably argue that research on GDSSs is less likely to lead to findings that are of direct interest to a wide range of organizations than research on asynchronous tools, particularly e-mail, which calls for at least a better balancing of research focus.

This unbalanced focus has been compounded by what seems to be a bias in groupware research in general toward experimental studies (Davison 1995), perhaps a consequence of the predominance of positivist research approaches in the IS field in general (Orlikowski and Baroudi 1991), and a lack of consistency in the research frameworks used (Pervan 1994). This may be one of the causes for the large number of contradictory research findings regarding groupware effects on group process and task attributes pointed out by DeSanctis et al. (1993). While there is no clear indication as to whether this is true, this research bias has almost certainly led to difficulties in the replication of findings in organizations. We believe that one of the main reasons for these difficulties is the suppression (or artificial inclusion), even in field experiments where little control is applied, of the effects of variables present (or absent) in actual organizational contexts, which can led to startling discrepancies in technology impact findings — for example, Orlikowski's (1992) study of the influence of organizational culture on the adoption of groupware technology.

We try to provide a shift of focus in both groupware technology and research approach used by focusing on the effects of asynchronous groupware support on PI groups and by using a research approach that tries to take into account the full richness of organizational interactions and yet exert no artificial control on the environment being studied. The asynchronous groupware tool used was e-mail conferencing (EC) and the main research approach used was action research.

2. RESEARCH METHOD

Organizational action research studies are characterized by the researcher applying positive intervention to the client organization, while collecting field data about the organization and the effects of the intervention (Lewin 1946; Peters and Robinson 1984; Jonsonn 1991). The client organizations of this study were School (pseudonym), a school of studies of a New Zealand university and MAF Quality Management (MQM), a branch of the Ministry of Agriculture and Fisheries of New Zealand, with offices spread throughout the country. Staff from eighteen different MQM offices and two departments in School participated in the research study.

The specific action research approach followed is detailed in Kock, McQueen and Fernandes (1995) and Kock, McQueen and Scott (1995). The approach is centered on the action research cycle proposed by Susman and Evered (1978), which comprises five stages: diagnosing, action planning, action taking, evaluating, and specifying learning, as shown in Figure 1.

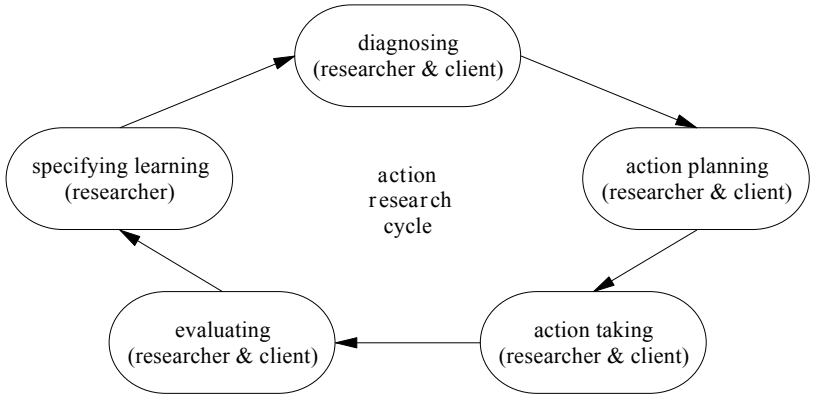

Figure 1. The Action Research Cycle

In the *diagnosing* stage, researcher and client organization identify and specify an opportunity of improvement in the client organization and match it with the research goals. In the *action planning* stage, researcher and client organization consider alternative courses of action to attain the improvement identified and devise a plan to implement one of these alternative courses of action. In the *action taking* stage, researcher and client organization implement the devised plan. In the *evaluating* stage, researcher and client organization assess the outcomes of the plan implementation. Finally, in the *specifying learning* stage, the researcher structures the information generated in the previous stage as general findings.

The study consisted of facilitating and studying seven EC-supported PI groups in the client organizations. These groups are referred to, in this paper, as G0 (at School) and G1 through G6 (at MQM), and have their main features summarized in Table 1. This table shows the number of members in each group, the number of electronic postings contributed by group members, the duration of the group in days, the number of departments and offices (or physical sites) represented in each group, and the group's scope of change. The study of G0 at School was conducted as a first iteration in the action research cycle, after which the researcher moved into the second, a final iteration with the study of G1 through G6 at MQM. The move across iterations provided a background for inter-organizational and longitudinal comparison of research findings, and allowed refinements of the research framework during the research study.

Table 1. PI Group Features

Group	Number of Members	Number of Electronic Postings	Duration (Days)	Departments Involved	Offices (Sites) Involved	Scope of Change
G0	7657111514	2179418236	3.32625e+13	2111463	11465108	interdepartmental
G1						departmental
G2						interdepartmental
G3						business
G4						business
G5						departmental
G6						interdepartmental

Departments are defined here as areas comprising interrelated functions performed by staff who share knowledge to perform interrelated activities[1] and may comprise staff based at different locations. This departmental structure mirrors the one used by MQM to classify staff according to service supplied, the basis for MQM's management structure,[2] where departments are part of a core business or a support division. This research study involved two main core businesses at MQM: Food, which comprised departments supplying dairy and meat-related services, and Plant, which comprised departments supplying plant-related services. The research also involved two support divisions at MQM: Information Technology Regional Support and Communications Support, which comprised departments supplying public relations, media liaison, document design, and business communication consulting services. School was considered as a business itself, from which one academic department and one support department participated in the study. Offices are defined here as physical aggregations of staff in the same building.

PI groups consisted of members from one or more departments, located in one or more offices. The scope of change of a PI group was said to be "departmental" when processes comprised by only one department were redesigned, even though the

[1]The referred interrelation between functions was defined by common knowledge required from staff to perform the functions, rather than by the functions being part of the same business process. For example, even though the *interrelated* functions "meat handling inspector" and "meat processing consultant" require common bodies of knowledge to be performed, only the latter is involved in the process of providing quality systems consulting.

[2]A dairy and food training manager in an office on the bottom tip of New Zealand's South Island, for example, ultimately reports to the national dairy/food manager based in Hamilton, on the North Island.

changes might have affected processes in different offices. The scope of change was called "interdepartmental" when the processes redesigned involved more than one department, but not a whole business (or support division). Finally, the scope of change was said to be "business" when the process redesigned involved the whole business (or support division), even though the PI group involved members of only one department (as in G3).

The groups followed a group methodology called MetaProi, discussed in detail in Kock (1995a). MetaProi was devised by the researcher (first author of this paper) based on normative frameworks for PI (Harrington 1991; Hammer and Champy 1993; Davenport 1993; Guha, Kettinger and Teng 1993; Wastell, White and Kawalek 1994; Kock 1995b), case studies (Dingle 1994; Caron, Jarvenpaa and Stoddard 1994), and a previous action research project in which general effects of EC support on PI groups were examined (Kock and McQueen 1995).

All PI groups had a leader, a facilitator and ordinary members. The facilitator in all groups was the researcher. All group leaders and ordinary members were staff of the client organization. The researcher provided technical and methodological support to the PI groups by interacting mostly with group leaders. The researcher influenced the structure of PI discussions by helping group leaders to build messages where individual contributions of group members were summarized and group stages were initiated and completed. No influence on the content of group discussions was exerted by the researcher.

The computer tool used to support the PI groups was a simple EC prototype, implemented using Groupwise[3] functions. Group e-mail distribution lists comprising PI group members were implemented for each of the PI groups using Groupwise rules.[4] The group distribution lists used in the research were similar to Internet list servers' electronic mail distribution lists (e.g., BPR-L and ISWorld[5]). The groupware tool allowed PI group members to exchange electronic messages within the group, and with staff of the respective organizations, as well as post messages and replies to the whole group. Spreadsheets, flow charts, presentations, and graphs could be attached as files to electronic messages, and read by recipients. Attachments could be read by clicking on icons on the computer screen.

2.1 Research Framework and Data Sources

A set of seventeen variables provided a basic framework for data collection. Those variables were derived from a set of seventeen research questions concerning three units of analysis, namely PI group member, PI group, and organization. Two of the units of analysis, organization and PI group, represented abstract entities — respectively, the client organization and the PI group. The third unit of analysis, the PI group member, represented a real entity — the PI group participant. The seventeen variables initially defined described attributes of the three units of analysis. Six of those variables were related to the unit of analysis organization, eight to the PI group, and three to the PI group member. This article deals with the PI group unit of analysis.

Research questions associated to the unit of analysis *PI group* were derived from literature review on small group theory (Shaw 1981; McGrath 1984) and empirical research on group effects of groupware support for work groups (Nunamaker et al. 1991; Ellis, Gibson and Rein 1991; Markus 1992; Pietro 1992; DeSanctis et al. 1993; Sheffield and Gallupe 1993; Alavi 1993, 1994; Gallupe et al. 1994).

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[3]Groupwise is an asynchronous group support system commercialized by Novell Corporation.

[4]Groupwise rules are simple programming structures that enable users to associate actions, such as distributing a message to a list of users, to certain events. An event may be an incoming message with a specific subject for example.

[5]BPR-L, administered by the University of Delft in the Netherlands, is a forum for the discussion of issues related to business process redesign. ISWorld, administered by the University College Dublin in Ireland, is a forum for the discussion of issues related to information systems research.

Data was collected through participant observation, interviews, questionnaires, and compilation of transcripts of electronic messages from PI group members. Complementary data about the organization and its main processes was obtained from internal archival records, such as service records and memoranda. Another source of complementary data were documents published by the organization, such as advertising material and the organization's internal newsletter.

Participant observation notes were generated based on the facilitation of PI groups and formal and informal interactions with staff. These notes were the result of perceptions and reflection about the researcher's interactions with the client organization and were intentionally framework-free; that is, they were not necessarily related to the set of research variables initially defined. This approach was adopted to provide a balance between framework-free sources of data (e.g., transcripts of electronic discussions, participant observation notes) and framework-bound ones (e.g., structured interviews), which, in turn, was expected to prevent the researcher from leaving out relevant effects unrelated to the initial set of research variables.

Interviews were of two types: structured and unstructured. Both types of interviews were based on open-ended questions (i.e., not restricted to a set of pre-defined alternatives). Structured interviews were based on a pre-defined list of questions and were taped and later transcribed. From three to six unstructured interviews per group were performed with group leaders and staff. These interviews lasted from one to three hours and were not taped. Data obtained through unstructured interviews was merged with participant observation notes for later analysis.

Structured interview respondents were PI group members who were based in Hamilton. Questionnaires with open-ended questions were sent via electronic-mail to PI group members based in offices outside Hamilton and followed up by phone. The questions in the questionnaires were the same as those used in the structured interviews. PI group members were interviewed or received questionnaires within two weeks of the completion of their groups. Transcripts of eleven structured interviews and seven questionnaires were obtained.

Participant observation notes were indexed by date and topic. These topics typically described a person or specific PI group and an event observed (e.g., John ignored other members' requests; Trish's group has had a low degree of interaction so far). Transcripts of interviews were indexed by the respondents name and topic. These topics were normally tightly related to one of the seventeen research variables. Transcripts of electronic messages from PI group members were indexed by PI group and date. Overall, approximately 135,000 words of descriptive qualitative data were generated. Most of it was in the form of interview and questionnaire transcripts (59% of the total), followed by participant observation notes (23%), and transcripts of electronic group discussions (18%).

3. PROCESS IMPROVEMENT METHODOLOGY

The process improvement methodology followed by the PI groups comprised three main stages, namely process definition, analysis and redesign. A description of the above stages for each of the PI groups is provided in Table 2. The table shows in the first column the proportions of time calculated as spent by group members on interactions through the EC system (EC) and orally (OR), totaled based on interaction times reported by members in structured interviews. Almost all oral interactions were one-to-one conversations face-to-face or over the phone.

In the definition stage, the group leader posts an electronic message to the group discussion with a general problem, a list of narrowly defined problems that are believed to be components of the general problem, a list of processes that are believed to be at the source of the problems, and a request for comments from group members refining this information and indicating which process (or few processes) the group should target. This first message is written by the group leader with the support of the facilitator.

In the analysis stage, the group leader and the facilitator summarize the group discussion following the first message in a new electronic message posted to the group discussion. This message typically contains acknowledgments to individual contributions, a flowchart or textual description of the process that the group decided to target, performance-related information about this process (e.g., number and types of users complaints, leading time, overall cost), a list of proposed changes to the

Table 2. Description of Group Stages

Group	Definition	Analysis	Redesign
G0 EC(71%) OR(29%)	Eight problems and three processes were listed. Four replies followed with comments and change suggestions.	Two processes were described (split into five activities each). Six changes were proposed. Ten replies followed refining the changes.	Five refined changes were listed with implementation deadlines. Four replies followed discussing implementation issues.
G1 EC(83%) OR(17%)	Three problems and two processes were listed. Two replies followed with change suggestions.	One process was described (split into five activities). Eight changes were proposed. Two replies followed refining changes.	Eight refined changes were listed with implementation deadlines. No replies.
G2 EC(89%) OR(11%)	Three problems and two possible processes with change suggestions. Three replies followed with change suggestions.	One process was described (split into eight activities), with three proposed changes. One reply followed refining those changes.	Three refined changes were listed, to be implemented right away. Two replies followed agreeing with changes and praising the initiative.
G3 EC(18%) OR(82%)	Three problems and two processes were listed. Two replies with general comments followed.	(face-to-face meeting)	Seven changes were listed, to be implemented right away. No replies.
G4 EC(80%) OR(20%)	One main problem was defined in a general and abstract way. Nine replies followed with general comments and raising new issues. No agreement on what should be discussed was achieved.	Previous postings were acknowledged. A set of problems and guidelines for action was proposed. Six replies followed. No agreement was reached.	Recognition that there was no agreement. Suggestion that the discussion should be conducted in a face-to-face meeting.
G5 EC(77%) OR(23%)	Four problems and five processes were listed. Nine replies emphasizing some of the problems and possible solutions.	Two processes were chosen based on the contributions and analyzed. Change suggestions were requested. Six replies followed with change proposals.	Five changes were listed with implementation dates. Five replies followed refining changes and praising the initiative.
G6 EC(67%) OR(33%)	A problem was defined and members were asked for information on how to build a software system to solve it. Five replies followed supplying information. Leader was dissatisfied with the results and decided to use the group as a forum for permanent exchange of information about software requirements.		

process with an indication of those who would be responsible for these changes, and a request for comments from group members refining the information provided and the proposed changes.

In the redesign stage, the group leader and the facilitator summarize the member contributions in the analysis stage in a final electronic message posted to the group discussion. This message typically contains acknowledgments to individual contributions and a brief plan with activities to be performed to implement the process changes agreed on by group members.

This brief plan includes a description of the activities, deadlines for their implementation, and those who are responsible for carrying out the activities.

3.1 A Brief Description of the Groups

G0 targeted two processes related to the teaching of a university course on business computing. The course was one of the most successful optional courses at School, with approximately 100 enrollments per semester. The need for process improvement was motivated by a disproportionate number of software and hardware complaints from students regarding the computer laboratories used during the course. All process redesign proposals generated by the group were implemented within a month after the group completion. Student perception surveys conducted every middle and end of semester indicated a "dramatic improvement" (in the words of one of the lecturers who routinely conducted the surveys) in the perceived quality of the course.

G1 targeted the process of providing software applications support to MQM's internal users. Three main problems triggered this group: (1) a perceived slow turnaround of software repair jobs; (2) a high number of complaints from users about not being notified about the "status" of their jobs; (3) lack of time to carry out LAN software maintenance. Six out of eight process changes proposed by the group were implemented within six months of the group completion. A qualitative evaluation of the changes conducted based on departmental staff perceptions indicated a slight increase in the perceived quality and efficiency of the process redesigned.

G2 targeted the process of editing MQM's internal newsletter. Three main problems motivated this group: (1) the lack of internal staff contributions to the newsletter; (2) several complaints about distortions in the articles provided by staff when they were finally published in the newsletter; and (3) the common delay in the publication of contributed articles. All process changes proposed by the group were implemented within three months of the group completion. The problems that originated the group were reported by the editor as having been completely eliminated as a result of the process changes.

G3 targeted the process of MQM's media liaison during pest and disease outbreaks threatening New Zealand's agriculture, which typically occurred no more than three times a year. This group arose from the need to improve the coordination of the several teams reporting outbreaks to the media (television, radio stations, and newspapers) in different parts of the country and, in consequence, avoid the release of misleading and inconsistent information about outbreak status. Four out of seven proposed process changes were implemented within four months of the group completion. An increase in the quality and the efficiency of the process was reported by members of MQM's media liaison team as a result of the process changes when it was brought into action again during a fruit-fly outbreak approximately seven months after the PI group was completed.

G4 targeted the process of providing quality systems consulting for MQM's external customers. This group arose from the need to adopt a new quality systems standard as the basis for one of the consulting products supplied by MQM, and to redesign some other consulting products, particularly in the food industry, in consequence. After nearly a month of heated debate no agreement was achieved. No process changes were proposed and the group discussion was seen as a failure by the group leader. A month later the same set of issues were discussed in a face-to-face group, but again no agreement was achieved.

G5 targeted the process of providing information technology (IT) support for MQM's internal users. This group was an extension of the discussion in G1 to deal with more general problems faced by the IT support team. Another difference was that this group involved fewer IT support staff in the group, as most of its members process customers. Four out of five process changes were implemented within six months of the group completion. A survey of customer perceptions indicated an increase in perceived process quality, while the staff's perceptions suggested an increase in the efficiency of the process. During the implementation of the process changes, the leader of the IT team was promoted to the position of regional IT support manager.

G6 targeted the process of coordinating staff training and development at MQM. Assuming that most group members previously agreed that the key point to improve the target process was to develop a computer system, the leader of this group tried to steer the group members into specifying the requirements of the computer system. The group members reacted to this attempt by posting some messages which were perceived by the group leader as "trivial" and suggesting lack of enthusiasm about the group discussion. After several phone and face-to-face contacts with group members, where they were asked to

contribute more and better structured information, the leader grew increasing frustrated and finally decided to use the group discussion as a forum for permanent exchange of information about software requirements rather than process improvement. The goal of this forum was to complement face-to-face meetings. This group was seen as a failure by the group leader from a process improvement perspective.

4. THE EFFECT OF ASYNCHRONOUS GROUPWARE ON PI GROUPS

A quantitative analysis of the perceptions of PI group members gathered in structured interviews allows us to form a basic picture of EC support effects on the previously identified group-related variables. The frequencies of responses were interpreted based on the assumption that if most respondents (i.e., more than 50 percent of the respondents) had the same perception, this would be an indication of a possible causal link.[6] Whenever this happened, we tried to gather more quantitative or qualitative evidence to support the existence of that link, and also looked for disconfirming perceptions and related evidence. In addition, data on group interaction and contribution length of the groupware supported discussions was collected and analyzed, and is presented at the end of this section.

4.1 Effects on Previously Identified Variables

Consistent with this approach, the analysis of response frequencies pointed to six main effects of EC support on PI groups, as shown in Table 3.

Table 3. Perceived Effects of EC Support on PI Groups
(Numbers shown are number of respondents and approximate percentages)

Variable	Increase	Decrease	No effect	Do not know
Process adoption	11 (61%)	0 (0%)	2 (11%)	5 (28%)
Hierarchy suppression	12 (67%)	0 (0%)	4 (22%)	2 (11%)
Dept. heterogeneity	16 (89%)	0 (0%)	1 (6%)	1 (6%)
Duration	2 (11%)	13 (72%)	2 (11%)	1 (6%)
Cost	1 (6%)	14 (78%)	2 (11%)	1 (6%)
Effectiveness	6 (33%)	3 (17%)	6 (33%)	3 (17%)

Respondents consistently indicated that EC support increased group process adoption, hierarchy suppression, and departmental heterogeneity. Moreover, no respondent indicated a perceived decrease in these three variables as a result of EC support. Respondents also consistently indicated a decrease in group duration and cost, as a result of the EC support. In the case of these two variables, however, there were a few dissenting responses. Finally, although there was no majority consensus about the effect of EC support on group effectiveness, perceived as directly linked to the quality of the redesign proposals generated by the group, most respondents perceived no negative effects on this variable.

4.1.1 Group Process Adoption and Hierarchy Suppression

The perceived increase in group process adoption fostered by EC support was strongly supported by the analysis of the interview transcripts and participant observation during the face-to-face facilitation sessions with group leaders. For example, almost all replies from members referred to messages posted by the group leaders — this can also be observed in Table 2 —

[6]The only exception relates group effectiveness, which is discussed regardless of majority respondent perceptions.

a behavior not commonly seen in face-to-face PI groups we facilitated in previous studies (Kock and McQueen 1995; Kock, McQueen and Baker 1996). In those face-to-face, groups leaders typically had to put a lot of effort into preventing group discussions from veering away from the main subject into new threads brought up by group members. In the EC-supported PI groups in our study, in contrast, this happened only once, in G4, and most group leaders indicated that it seemed to be much easier to lead EC-supported PI groups than face-to-face PI group discussions. Moreover, two group leaders admitted having severely limited leadership skills and therefore not being able to lead a face-to-face group discussion with the members that were in their EC-supported PI groups. In one of these cases the group leader was one of the most junior staff in his group and his national business manager was a member of the group. In the other case, the group leader was the most junior person of his group. These cases also provide support to the perception that EC support decreases the influence that status differences in the organizational hierarchy have on how individual contributions are perceived by members, an effect referred to in this study as group hierarchy suppression.

It is important to explain the reason why we use the term EC "support" rather than EC "mediation" in this study. The analysis of computer mediation effects would typically require us to run some PI groups where interaction was only through the EC system and some PI groups where interaction was exclusively face-to-face (control groups). We, however, opted to offer EC support optionally to the PI groups.

Requesting PI groups to interact only through the EC support system would allow us to make assumptions about EC mediation effects, but would at the same time apply artificial control on the PI groups being studied and probably bias the results — i.e., PI groups would tend to see their work as part of a field experiment, which could reduce their willingness to contribute to the group discussion or their commitment to the process redesign proposals generated by the group. Since this was an action research study, and therefore one of our goals was to actually improve the client organizations through the PI groups rather than merely use those organizations as laboratories, we offered both the group methodology MetaProi and the EC system as alternative tools to be used by the PI groups, that would in our view likely increase those groups' efficiency and effectiveness. We made it clear that we had no objection to a group running the whole group discussion or most of it through face-to-face meetings, which was what group G3 did. Even so, all PI groups but G3 ran all their group discussions through the EC system, using face-to-face, phone and ordinary electronic mail messages only for one-to-one conversations.

4.1.2 Group Departmental Heterogeneity

Perhaps the preference of PI groups for the EC system over face-to-face meetings as the main communication medium was motivated by the higher departmental heterogeneity found in the groups, which may suggest a higher group site heterogeneity, as organizations often group together staff from the same department and separate departments by walls and distance (e.g., departmental staff are grouped on different floors or in different buildings). We found support for this hypothesis when we looked at the main reasons given by respondents for their perception that EC support increases departmental heterogeneity in PI groups. These reasons were:

- That EC support enables group discussions to be carried out without affecting individual timetables (eight respondents).

- That EC support reduces the influence of distance (five respondents).

The first reason can be interpreted as a reduction caused by EC support in the perceived disruption that PI group discussions can have on members' routine (or functional) activities. However, the second reason can only be explained by an underlying correlation in the organizations studied between departmental heterogeneity and site heterogeneity. This underlying correlation was confirmed by a correlation test between the numbers of departments and sites involved in the PI groups shown in Table 1. The Pearson correlation coefficient obtained for this test was 0.70 ($P<0.05$, 1-tailed test), which indicates a strong correlation between number of departments and number of sites in the PI groups studied.

In addition, only one group, G1, involved staff from only one department and who were located in the same site. While the members of this group found EC support useful, particularly because some of them worked in different shifts and the majority

spent most of their time outside the office, other prospective leaders of similar groups did not show much interest in using the approach proposed by the researcher. A comment by one of these prospective leaders illustrates this lack of interest: "Why would we interact through [the EC system] when we can talk to each other at any time?....[T]here is no use for this system here."

These results suggest that the usefulness of EC support may increase with the number of departments involved in PI groups, even though it may also be useful to departmental PI groups provided there is some sort of time or distance constraint that prevents group members from meeting face-to-face (e.g., different shifts).

4.1.3 Group Duration

A high percentage of structured interview respondents (72%) perceived EC support as decreasing PI group duration. The main reason given by these respondents was a reduction in group set up time, which was perceived as the time spent inviting prospective members to participate in the group discussion, choosing and booking a venue for group meetings, negotiating a meeting schedule, and reminding members to attend meetings. Obviously, the need for the three last activities would be totally eliminated in EC-supported PI groups where all interaction takes place through the EC system.

However, a few respondents (two out of eighteen, or 11%) were of the opinion that EC support actually increases PI group duration. These respondents were unanimous in the reason given for this: a perceived increase in the time that each member takes to contribute. In fact, several structured and unstructured interview respondents implicitly supported this view by noting that it was more time consuming to post a message to the group discussion than make an spoken contribution and that the low control over individual participation in EC-supported PI groups allowed them to give low priority to posting messages to group discussions. We also compared the time required to create and post an electronic message with that required to make a spoken contribution, and to read a posting in a PI group discussion. This comparison was based on estimates of the spoken word rate in taped interviews[7] (3.33 words per second), the posting creation and typing rate in EC contributions (6.93 words per minute, or 0.12 words per second), and the word reading rate for electronic messages (2.89 words per second). The comparison indicates that it is severely more time consuming (3.33/0.12 = 27.75 times) to contribute through the EC system than it is to contribute in a face-to-face meeting. On the other hand, reading is only 1.15 times faster than listening.

An analysis of the transcripts of electronic discussions also shows that there is a considerable lag between the leader's messages and replies from group members. While the minimum lag was slightly less than one hour, the maximum lag was 193 hours, that is, over eight days. The average lag was 73 hours, or approximately three days. This means that group leaders would typically have to wait three days for replies to their main messages, before they could proceed any further in the group discussion.

Finally, while the duration of five out of the seven PI groups studied (G0, G1, G2, G4, and G5) ranged from 25 to 33 days, G3 was completed in only 14 days. Since a narrow scope of change of G3 — "business" according to Table 1 — cannot be used as a valid explanation for the fact that this group was completed faster than the others, it seems to be plausible to say that G3 lasted less than the other groups because the analysis stage had been run through a face-to-face meeting.

While the results presented in this section point to EC support factors that may cause an increase in the duration of PI groups, these results also suggest that the combination of EC-supported and face-to-face group discussions is likely to decrease PI group duration, as the interview respondents' perceptions indicate. That is, while a purely EC-mediated PI group may not be completed in less time than a PI group in which interaction was purely face-to-face, the "support" provided by the EC system seems to be likely to reduce PI group duration.

[7]We assumed here, based on our previous facilitation of face-to-face PI groups, that the average word input rate would be almost the same in taped interviews and face-to-face PI group meetings.

4.1.4 Group Cost

A high proportion of structured interview respondents (78%) were of the opinion that EC support decreases the cost of running PI groups, which involved transportation and communication as well as member participation time costs. Respondents explained this reduction in group costs as resulting from three main factors: (a) a reduction in the disruption of member functional activities (i.e., the routine activities associated with their functional position in the organization), and therefore of the costs generated by this disruption (e.g., quality costs); (b) a drastic reduction in transportation and communication expenses in groups involving members based in different cities, since PI group members would not have to travel to participate in the discussions nor would have to call their offices to be up-to-date with local developments; and (c) a considerable reduction in member participation times in the case of ordinary members, and a slight reduction in the case of group leaders.

While factor (a) is difficult to measure and factor (b) was too trivial to warrant further analysis, we thought that a simple quantification of factor (c) would lend more weight to our findings. In the structured interviews, respondents were asked how much time they spent on the group discussion. That time averaged 1.5 hours for ordinary members, and seven hours for group leaders. Some members who declared having participated in face-to-face PI groups before were asked to estimate the amount of time they would had spent on their PI group discussions had those discussions been conducted only through face-to-face meetings. These estimates averaged twenty hours. This suggests that ordinary members' participation time had been reduced by approximately 92 percent (1-1.5/20 = 0.925) due to the EC support, whereas the reduction for group leaders was of 65 percent (1-7/20 = 0.65).

4.1.5 Group Effectiveness

A third of the structured interview respondents (33%) saw EC support as having increased group effectiveness. In addition, although 17 percent were of the opinion that EC support decreased group effectiveness, another 33 percent believed that EC support had no effect on this variable. That is, 66 percent of the respondents were of the opinion that EC support had no negative effect on group effectiveness.

All but one of the respondents who thought EC support increased group effectiveness explained this effect by an improvement in the quality of individual contributions fostered by the asynchronous and written communication medium. According to the respondents, an asynchronous discussion allows them enough time to reflect on other members' contributions, whereas the written mode of communication lead them into carefully structuring their ideas and preparing better thought out contributions. One of the respondents, on the other hand, assigned the increase in group effectiveness to a better distribution of contributions fostered by EC support.

Those who saw EC support as neither increasing nor decreasing group effectiveness explained their answer by a balance of positive and negative effects. According to these respondents, EC support increased the quality of individual contributions but in turn decreased member participation, which led to a neutral effect on group effectiveness. These perceptions, to a certain extent, were consistent with the perceptions of those respondents who thought that EC support decreased group effectiveness. According to these, the main reason is a decrease in member participation induced by EC being the primary means of communication.

The higher perceived quality of individual contributions is consistent with two primary EC support effects on groups. One of these is an increase in the length of individual contributions, which is discussed in the next section. The other effect, observed during the facilitation sessions with group leaders and reinforced by participants' comments in unstructured interviews, is the particular care that members take when preparing electronic postings. Several group leaders, for example, read their messages several times before posting them to the group, often clarifying ideas, itemizing main points and using terms perceived as less "ambiguous." On a number of occasions, group leaders were, after carefully preparing their contributions, still reluctant to click on the "send" button to post their messages to the group, often looking at the researcher and asking "Are you sure [the message] is ready? Maybe I should read through it again a couple more times and post it to the group in a few days," to which the researcher sometimes responded by taking over the mouse and clicking on the "send" button for them.

On the other hand, the negative EC support effect of reducing member participation and thus perceived group interaction was also confirmed by our analysis of electronic discussion transcripts, as discussed in the next section.

4.2 Group Interaction and Member Contribution Length

Two variables that were not part of our initial research framework, but whose dependence on EC support became evident during the facilitation of PI groups, are group interaction and individual contribution length. Group interaction was defined as the number of individual contributions per active group member (i.e., a group member who made at least one contribution to the group discussion). Member contribution length was defined as the number of words per contribution.

The interaction in face-to-face meetings can be rapid — for example, McQueen's (1991, Chapter 4) field study of business meetings reported an average duration of twelve seconds for individual contributions. In a group with seven members that met for five hours, for example, this rate would account for approximately 214 contributions per member (5*60*60/12/7 = 214.29). Given our previous estimate of 3.33 words per second for spoken contributions in face-to-face meetings, a typical individual contribution in a face-to-face meeting would have 40 words (3.33 x 12 = 39.96).

In the PI groups studied, however, the EC support was perceived by members as having led to a considerable decrease in group interaction. Almost invariably we noticed that group leaders expected to see more interaction in their groups, with some group leaders having the expectation that group interaction was going to be higher through the EC system than it would be in face-to-face meetings. The frustration of these expectations led a few group leaders to feel affronted and ignored by the other members, and in one of the cases (G6) this contributed to the group leader discontinuing the group discussion.

In order to quantify the impact of EC support on group interaction and contribution length, we calculated the number of words of individual postings in PI group discussions, as well as the number of messages per active member in each of the groups. The smallest posting was three words long, and the largest was 784 words long, with an average of 260 words per posting. In addition the number of postings per active group member varied from one (G6) to 4.2 (G0), with an average of 2.25 contributions per group member.[8] These estimates, when compared with those for face-to-face discussions, indicate that while EC support can increase the length of individual contributions, it can also drastically decrease group interaction.

5. DISCUSSION

The research findings support the general assumption that EC support is more likely to be beneficial than detrimental to PI groups and warrant the recommendation for organizations to try and use EC and other asynchronous groupware technologies to support PI projects. The research findings are also consistent with previous findings regarding GDSS effects on PI groups, and in fact with most of the empirical literature on synchronous groupware, which indicate major productivity and slight quality gains from a group task perspective (Dennis, Hayes and Daniels 1994; Reinig et al. 1995).

The reasons why these gains are achieved, however, seem to differ considerably for synchronous and asynchronous groupware. While GDSS support effects on group productivity and outcome quality are often associated to an increase in the quantity of ideas generated by the group (Nagasundaram and Bostrom 1994), our findings suggest other factors related to EC support. Main factors affecting group productivity seem to be an increase in group process adoption and discussion focus, which apparently decreases losses caused by parallel discussions unrelated to the main topic of the group discussion, and a drastic decrease in group set up costs. In the same line, main factors affecting group outcome quality and thus effectiveness are an increase in the quality of individual contributions, rather than in the number of contributions as in GDSS-supported groups (in fact, in EC-supported groups the number of individual contributions seems to be drastically reduced). Moreover, EC support

[8]We are disregarding here the one-to-one oral interactions that accounted for 11 to 33 percent of the interaction in six of the groups. Nevertheless, the research results lead us to believe that the more the EC medium is used for communication in PI groups, the more pronounced is the decrease in the group interaction.

seems to allow PI group discussions to be conducted over a longer period of time, with more reflection on the part of the members, even though it is perceived as reducing the duration of PI groups when compared with no groupware support at all.

The analysis of the effectiveness of some of the PI groups raises serious questions as to the current focus, pointed out by Nagasundaram and Bostrom, on the analysis of number of ideas as a measure of group effectiveness. Even though no direct quality assessments were conducted on the process redesign proposals, the analysis of some groups indicate that group success is not always related to the number of individual contributions or ideas. In G1, for example, the number of individual contributions (and ideas) was considerably lower than in G4. Nevertheless, the effectiveness of G1, which succeeded in improving a process, was higher than in G4, which failed.

One of the most influential theories of media choice in organizations is the information richness theory (Daft and Lengel 1986). It is interesting to note that while some of our research findings are inconsistent with predictions based on this theory, some other findings support the theory to some extent. Information richness theory states, for example, that the filtering of non-verbal cues and the lack of an immediate feedback characteristic of asynchronous groupware interaction tends to increase the "equivocality" (or ambiguity) in the group discussion. One could quite reasonably predict based on this hypothesis that group members would perceive a decrease in the quality of individual postings as a result of increased use of EC for interaction. However, what happened was exactly the opposite: the majority of the structured interview respondents perceived an increase in the quality of individual contributions. The reason for this increase seems to be, as a number of previous studies (Markus 1992, 1994; Orlikowski et al. 1995; Lee 1994) and emergent theoretical approaches (DeSanctis et al. 1993) pointed out, that users adapted their use of the technology based on social norms in ways that allowed groups to overcome the limitations believed as being inherent in the specific communication medium used.

On the other hand, in groups where the complexity or abstraction of the issues being discussed by the group was perceived as high, the reaction was consistent with information richness theory. In G4, for example, the high level of abstraction in the discussion was perceived by some members as contributing to the group failure. By the same token, G6 tried to undertake a task, software requirement specification, that was, in the view of the group leader and some members, too complex to be conducted through the EC system. The members in this group had agreed on neither the technical language to be used in the group discussion nor the structure of the specifications — some used software engineering terms and data structure representations to convey their ideas, while others used specific terms of their respective business jargon — before the discussion was begun. Several members pointed out that the combination of lack of immediate feedback and higher contribution effort in the EC-mediated portions of the discussion led them to refrain from asking other members for clarifications about idiosyncratic terms and language used, and eventually put them off the discussion.

We could speculate, based on the discussion above, that the consideration of the adaptive power of social groups to overcome equivocality is a fundamental ingredient in explaining the interaction between asynchronous technology and PI groups, but that, on the other hand, in extreme situations (e.g., very high task complexity) the predictions of information richness theory can hold. In this sense, a theoretical perspective that takes into account this adaptive power, such as adaptive structuration theory (DeSanctis et al. 1993) for example, could be seen as analogous to the Newtonian Theory of Mechanics, which explains physical phenomena reasonably well at low speeds (low group task complexity), but that must give way to Einstein's Theory of Relativity to explain physical phenomena when the relative speed between physical systems approaches the speed of light (high group task complexity). Both theoretical frameworks are ingenious and relevant, but have their scope of application defined by a threshold — speed (task complexity).

6. POTENTIAL SOURCES OF BIAS

The research findings in this study may have been biased by the high involvement of the researcher with the groups and organizations studied and by the small sample examined of some units of analysis.

Our facilitation of PI groups may have led those groups to behave in an artificial way, exactly what we wanted to avoid by using action research. We tried to minimize this source of bias by refraining from influencing the content of the group discussion and "proposing" the group methodology and groupware technology as supporting tools for the groups but not trying

to impose them on the groups. While the former strategy seemed to be successful, as several group members declared being unaware of the involvement of the researcher until they were asked to be interviewed, the latter was partially unsuccessful to the extent that most of the researcher's suggestions regarding group process structure were adopted by the groups: most groups followed the same group methodology, MetaProi (Kock 1995a). This factor, along with the fact that the facilitation role performed by the researcher may not be available in a number of organizations, must be taken into consideration in the assessment of the likelihood of replication of our findings in other organizations.

The small sample of some units of analysis may have distorted some conclusions. It should be noted, however, that findings based on comparisons across groups are based on a smaller sample (N = 7) than those based on the comparisons of respondent perceptions (N = 18) and electronic messages (N = 88). Moreover, all findings were supported by multiple sources of data — notably, participation observation, unstructured and structured interviews, and electronic discussion transcripts. Nevertheless, we believe that the findings in this study should be seen as descriptive and preliminary.

7. CONCLUSION

This research has addressed the effects of asynchronous groupware support on group oriented factors for groups engaged in process improvement activities. From the view of the participants in the study, asynchronous groupware was perceived to have increased group process adoption, hierarchy suppression, departmental heterogeneity and contribution length, and decreased duration and cost. Participant perceptions also suggest no negative effects on group effectiveness. All of these effects are seen as positive improvements in the operation of these groups.

However, asynchronous groupware as a medium for discussion seemed to have been responsible for decreased interaction (turn sharing in the discussion) below that which might be expected to be typical of similar face-to-face meetings. This finding implies that while asynchronous groupware shows promise as a medium of support for process improvement activities, it may not be suited to support process improvement activities in which a high level of interaction is needed in order to, for example, clarify points about a complex process or build commitment toward a risky decision. We believe that the likelihood that these characteristics will be present in improvement groups increases as groups move from gradual and localized toward radical and broad process change proposals. We therefore believe that as this move occurs so does the need for a combination between groupware-mediated and face-to-face discussions in process improvement groups.

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