# Lessons from a Dozen Years of Group Support Systems Research:

# A Discussion of Lab and Field Findings

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## Abstract

*During the past dozen years researchers at The University of Arizona have built six generations of group support systems software, conducted over 150 research studies, and facilitated over 4,000 projects. This article reports on lessons learned through that experience. It begins by presenting a theoretical foundation for the Groupware Grid, a tool for designing and evaluating GSS. It then reports lessons from nine key domains:*

1. *GSS in organizations*
2. *Cross-cultural and Mulicultural Issues*
3. *Designing GSS software*
4. *Collaborative writing*
5. *Electronic polling*
6. *GSS facilities & room design*
7. *Leadership and facilitation*
8. *GSS in the classroom*
9. *Business process re-engineering*

## 1 Introduction

A great deal of work gets done by individuals who set their jaws, put their shoulders to the wheel, and bear down. However, many problems organizations face cannot be solved by the rugged individualist because no one person has all the experience, all the resources, or all the information to accomplish such a task alone, and so teams form. Teams of people have successfully scaled seemingly insurmountable heights. But teamwork brings its own set of problems. All who have suffered the grinding drudgery of meetings-without-end know how unproductive teamwork can be.

Many things can go wrong with teamwork [76]. Participants may fail to understand why their goals, may lack focus, or may have hidden agendas (Figure 1). Some people may be afraid to speak up, while others may dominate the discussion. Misunderstandings occur through differences of language, gesture, or expression.. Besides being difficult, teamwork is expensive. A meeting between several managers or executives may cost upwards of $1000 per hour in salary costs alone. There are more than 11 million formal meetings per day in the United States alone, more than three billion meetings per year. Managers spend about 20% of their time in formal meetings of five people or more, and up to 85% of their time communicating [61]. One Fortune 50 company reports losses in excess of $75 million per year due to poor meetings.

For all its difficulty, teamwork is still essential; for all the expense, teams will not go away. People must still collaborate to solve tough problems. And, as business becomes more global in scope and computers become more ubiquitous in the workplace, the need for collaboration – and computer-based collaboration – will surely continue to increase.

Group Support Systems (GSS) are interactive computer-based environments which support concerted and coordinated team effort towards completion of joint tasks. Besides supporting information access, GSSs can radically change the dynamics of group interactions by improving communication, by structuring and focusing problem solving efforts, and by establishing and maintaining an alignment between personal and group goals. This paper presents a useful model for analyzing and comparing GSS technologies. It then summarizes the lessons learned from a dozen years of developing, testing, and using group support systems.

[FIGURE 1 ABOUT HERE]

### *1.1 Groupware and Group Support Systems.*

Before discussing group support systems in detail, it is useful to clarify their place within the wider domain of groupware, and to explain the diversity of contributions groupware can make in an organization. Toward that end, consider the Groupware Grid, which can serve as theory-based heuristic model for evaluating the contributions of groupware technology to team productivity (Figure 2).

#### 1.1.1 Team Theory and the Groupware Grid.

The horizontal axis of the Groupware Grid derives from the Team Theory of Group Productivity [9]. Webster's Dictionary defines a team as a collection of people working together for some specific purpose. Team Theory is a causal model for the productivity of a team. It asserts that team members divide their limited attention resources among three cognitive processes: communication, deliberation, and information access. Team Theory posits that these processes interfere with on another, limiting group productivity.

Team Theory's communication construct posits that people devote attention to choosing words, behaviors, images, and artifacts, and presenting them through a medium to other team members. Team Theory's deliberation construct asserts that people devote cognitive effort to forming intentions toward accomplishing the goal. It includes the classic problem-solving activities: Make sense of the problem, develop and evaluate alternatives, select and plan a course of action, monitor results, etc. The information access construct addresses the attention demands of finding, storing, processing, and retrieving the information the group members need to support their deliberation. Team Theory posits that a key function of information is to increase the likelihood that one will expect the outcome one obtains by choosing one course of action over another. Information has value to the extent that it is available when a choice must be made, to the extent that it is accurate, and to the extent that it is complete. However the value of information is offset by the cost of acquiring, storing, processing, and retrieving it.

Team Theory also posits that the cognitive effort required for communication, deliberation, and information access is motivated by goal congruence - the degree to which the vested interests of individual team members are compatible with the group goal. Team members whose interests are aligned with the group's will exert more effort to achieve the goal than those whose interests are not served by the group goal. The Groupware Grid does not address goal congruence because goal congruence may have more to do with the way a team wields the technology than with the inherent nature of the technology.

Therefore, the horizontal axis of the grid addresses the potential for technology to reduce the cognitive costs of joint effort. Groups may become less productive if the attention demands for communication, deliberation, or information access become too high. Groupware may improve productivity to the degree that it reduces the attention costs of these three processes.

[FIGURE 2 ABOUT HERE]

#### 1.1.2 Three Levels of Group Work and the Groupware Grid.

The vertical axis of the Groupware Grid consists of three levels of group effort (Figure 3). Sometimes a team may operate at the Individual Work Level, making individual efforts that require no coordination. As with people in a 100 meter dash, group productivity is simply the sum of individual results. Other times a team may interact at the Coordinated Work Level. At this level, as with a team in a relay race, the work requires careful coordination between otherwise independent individual efforts. Sometimes a team may operate at the Concerted Work level. As in a rowing race, teams working at this level must make a continuous concerted effort. The demands placed on the team vary depending on the level of work in which they are engaged. There is groupware technology to support teams working at all three levels.

[FIGURE 3 ABOUT HERE]

One can map the contributions of a single groupware tool or an entire groupware environment into the cells of the Groupware Grid. A given technology will probably provide support in more than one cell. One can compare the potential for productivity of different environments by comparing their respective grids. For Example, a team database like Lotus Notes offers little support at the Concerted Work level but offers strong support for communication and information access at the Coordination Level. A team database offers little deliberation support at the Coordination Level, but project management and workflow automation system offers strong deliberation support at that level.

The work at The University of Arizona has focused on GSS aspects of groupware. GSS offers a great deal of support for communication, deliberation, and information access at the Concerted Work level (Figure 4). For example, parallel input and anonymity are two communication interventions possible with GSS to improve communication during a concerted effort. Each software tool in an GSS supports group deliberation in some unique way. A brainstorming tool, for example, prevents a group from thinking deeply, while encouraging them to diverge from familiar thinking patterns. An idea organizer, on the other hand, encourages a divergent group to focus quickly on a narrow set of key issues. Other tools might include electronic polling and voting, multicriteria evaluation, team outlining and writing, and shared drawing tools, to name but a few. GSS might support information access at the concerted work level by providing rapid access to the information in the minds of teammates, by providing a permanent transcripts of past electronic interactions, or by providing an information search engine.

[FIGURE 4 ABOUT HERE]

This paper describes the lessons learned and the knowledge that has evolved from the building and use of GSSs at The University of Arizona over the past dozen years. The earliest GSS work at Arizona was implemented on a VAX. It focused on supporting geographically-separated teams working on requirements definition for large information systems development projects. It quickly became clear, however, that these teams had no frame of reference for their on-line interactions. GSS interactions were different enough from common experience that people had no mental model upon which to base their distributed interactions. Further, because on-line interactions so far outside the realm of normal experience, it was very difficult to explain the concept, even though the technology was very easy to use.

We therefore developed the concept of the electronic meeting room, and spent a decade researching the technology and techniques to make teams productive as they interacted face-to-face. Building on what we learned, we turned our attention once again to supporting distributed teams. Our research center currently has 22 projects dealing with various aspects of distributed GSS. The problem is still difficult, but it is no longer intractable. In this paper we summarize a great deal that we have learned in the lab and in the field about supporting face-to-face teams. We also touch on the preliminary findings of our more recent work in supporting distributed teams.

## 2 Lessons From Research

Over the past twelve years of research and development of collaboration technology, we have discovered much at the University of Arizona about the nature of the interactions among people, technology, and tasks. Our research methods have included case studies, field studies, and laboratory experiments. The findings from these studies have contributed to the fabric of understanding we have woven over time. The complex and multifaceted nature of Group Support Systems requires that a variety of efforts and methodologies be called upon to address the multitude of research questions that exist. Our research philosophy is to develop systems, methods, and environments in an evolutionary, longitudinal, multimethodological research program. Given this approach, we build on the theoretical foundation of prior information systems, psychology, and communications research by examining the process and outcomes of forms of group work not previously possible.

Our direct experience is based upon have work with more than 200 public and private organizations in our own four meeting laboratories as well as at over 1,500 sites around the world built upon the meeting laboratory model established at Arizona. We have facilitated or supported over 4,000 working sessions for teams and have produced more than 150 research studies in the domain of collaborative technology during the past decade. The lessons learned we now report stem from this body of research.

### *2.1 Lessons on GSS in Organizations*

While much of the initial GSS findings at Arizona, Minnesota and other pioneer GSS centers came from the laboratory, researchers early on noticed differences between lab and field findings [22]. Actual field use of GSS was producing impacts which were not modeled nor measured in the early lab experiments. Many of these impacts was due to the fact that real groups do not perform tasks in a void, but within an organizational context which drives objectives, attitudes and behaviors in group meetings. While working with hundreds of groups in the field we have learned a number of lessons about GSS and organizations. Some of the following discussion stems from findings previously reported; other portions of the discussion have been collected by CMI researchers but not previously reported due to confidentiality constraints at the time of the study or other related limitations.

[TABLE 1 ABOUT HERE]

### 2.1.1 GSS and Organizational Buy-In to Decisions.

The use of Group Support Systems may increase the likelihood that participants will buy in to the final results of the group effort. For example, a task force in a large bureaucratic organization tried for over a year to draft a document detailing acceptable field procedures. In that time they were not able to persuade both the field experts and the central administration to accept the same draft of the document, despite a long series of meetings. The team decided to bring the field experts and the administrators to an GSS facility for another try. Using anonymous brainstorming, group writing, and electronic voting tools the group quickly identified the key issues standing in the way of resolving the disputes. Within three days the group had negotiated their differences and rewritten the bulk of the document. The revised document was accepted and used thereafter by both sides. Because all parties worked simultaneously, a unified shared vision emerged, and key constraints from both sides could be incorporated into the document. Both sides bought in and championed the final draft back to the rest of the organization.

The field studies clearly show that substantial benefits, both economic and intangible, accrue from the use of Group Support Systems. Experience also shows that success depends on both the way the tools are designed and how they are used.

### 2.1.2 Leadership.

Much of what we know about GSS and leadership can be summed up in the maxim,

*GSS Technology does not replace leadership*

A GSS can move a group through a process much more quickly than is possible by conventional means. If the group is headed toward a clearly defined goal, the GSS can help achieve the goal more productively. If the group is unclear about its goal, the lack of direction will become immediately obvious when the team begins work. Such undirected teams often abandon the meeting process within 10 or 15 minutes. GSS does not replace leadership, but it can enhance the effectiveness of a well-led team.

GSS technology does not enforce a particular leadership style. It has been appropriated in support of a variety of approaches, ranging from democratic to autocratic; in situations, ranging from chaotic to static; and in organizational cultures, ranging from fragmented to cohesive.

GSS technology can help resolve counterproductive conflicts between leadership styles. One manager, who considered himself to be very democratic, presided over weekly 2 1/2 hour planning meetings with his staff. For the first hour and a half he would let the staff speak, but then he'd grab a felt marker and move to the whiteboard with the comment, "Let me see if I understand what you're saying." He would then describe his own agenda using words and phrases culled from the group discussion. This vice president's superiors recognized the problem and decided to try using an GSS to alter his autocratic management style. The staff was enthusiastic about the results, but he was not; he could no longer dictate the agenda, and he ultimately decided to stop using the system. The staff, with the support of top management, refused to let him. Group morale rose quickly, and the team prospered under a new, shared vision.

Failure to make a meeting's objectives explicit can lead to disenchantment, particularly when participants spot phony democracy. If a leader includes a group in the decision-making process after the fact simply to "let them feel ownership," the group process breaks down. Leaders who merely want a team to understand a problem before they propose a solution should say so up front. If the objective is to develop a set of alternatives and recommendations, if should be so defined. Once the team has been commissioned to make a decision, however, a leader can contribute, advise, and argue, but the team will rebel against a leader who overrides its collective judgment.

False promises of anonymity are equally damaging. Any attempt to find out who said what in an anonymous session undermines the leader's credibility and defeats the purpose of anonymous input, which is to solicit risky, unpopular, or opposing viewpoints.

### 2.1.3 Role Clarification.

Group support systems can also be used to identify those with a stake in a project, and reveal underlying assumptions. When a national library attempted to develop a computer system, it formed a team composed of representatives from different departments such as circulation, cataloging, acquisitions, and computing. For several meetings the groups tried and failed to develop a shared vision of the project. The team leader decided to use an electronic stake-holder and assumption-surfacing tool.

It turned out that the various departments had unrealistic expectations of the computer group, and the computer group had unrealistic expectations about the others. During the next few months, through vigorous and sometimes acrimonious debates, the team arrived at a common understanding and a shared vision. Until the participants engaged in stakeholder analysis they had not even been aware that fundamental differences existed. The group support system allowed them to share critical information and correct mistaken assumptions, solving an intractable problem and fixing a major oversight in the process.

Any tool is only as good as the artisan who wields it. This is just as true of sophisticated group support software as of a screwdriver. To realize these systems' enormous potential to expand the productivity of today's team-oriented organizations, leaders must recognize both tangible and intangible benefits. The intangibles, which depend heavily on the style and quality of leadership, include greater group cohesiveness, better problem definition, a wider range of higher quality solutions, and stronger commitment to those solutions. The tangibles, already demonstrated, are dollar savings through greater productivity and reduced staff hours to reach decisions. On the bottom line, more time is free from the demands of frequent -- and often frustrating -- meetings.

### 2.1.4 GSS and Participation in Organizational Activities.

The members of teams that use GSS participate much more evenly and fully in team interactions than do members in conventional teams. Laboratory experiments [11] and field studies [7, 68] have shown that Pareto’s law applies to conventional meetings: fewer than 20% of the participants do more than 80% of the talking. People in GSS supported meetings participate nearly equally, and produce many more contributions than do people in unsupported meetings. Two key features of GSS may account for this increase in participation: anonymity and parallel input [56].

[TABLE 2 ABOUT HERE]

However, use of GSS is not always enthusiastically welcomed by organization members. If organizational rewards are based on individual performance, information access, or specialized knowledge, it may well be more rational for individuals not to actively participate in GSS sessions where information is shared and ideas are contributed anonymously. It is important that organizational incentives and rewards be aligned with GSS use or GSS implementation can fail.

### 2.1.5Lessons about Anonymity.

Laboratory studies have shown that when groups use a GSS to generate ideas, groups using GSS produce many more unique ideas of higher quality than groups using standard meeting techniques [23, 29, 30]. Further, laboratory studies showed that teams using anonymous GSS contributed many more ideas when they were allowed to enter both positive and negative comments [14]. Theory suggests [25], and field experience confirms, that the anonymity provided by a GSS frees people to explore or to criticize ideas without fear of retribution from peers or superiors. It encourages people to participate in generating without inhibition. A manager at A Hughes Aircraft observed, "People who are usually reluctant to express themselves feel free to take part, and we've been surprised by the number of new ideas generated. We also reach conclusions far more rapidly."

Anonymity is a continuous rather than discrete construct [56] and GSS facilitators have found ways to manipulate varying degrees of anonymity to achieve their goals. For example, a GSS can be used to support discussion without any identifying signature tied to individual comments. While some participants may believe they can identify their correspondents, they can't really know for sure and experience has shown that such guesses are most often incorrect. Partial anonymity can be introduced in a variety of ways. Participants can by asked to use an alias so that all of their comments are attributed to the same author, but other participants do not know which real person that author is. We often use American Presidents for aliases. Also, participants can have their comments labeled by their sub-group membership (e.g.: teachers, parents, administrators at a PTA meeting) so sub-group membership is pegged to a comment, and hence the position that participant is likely coming from, but individual anonymity is maintained.

When they first hear about anonymous input some people express concern that the discussion will quickly degenerate into "flaming" sessions where participants launch vitriolic personal invectives laced with four-letter words and slanderous epithets. In thousands of sessions in business and government organizations, however, we have seen only two such disintegration. This does not mean, however, that people are not critical in electronic meetings. They are. Participants will often raise issues that would never come out in face-to-face discussions. There is less sting in an anonymous electronic criticism than in a direct rebuke during a face-to-face meeting. The screen buffers the negative emotions that may accompany such criticism. Because nobody knows where a particular idea came from people criticize the idea rather than the person who presented it. However, we have seen egos get bruised and people having difficulty dealing with honest feedback.

Anonymity may also encourage group members to view their ideas more objectively and to see criticism as a signal to suggest other ideas. "I wasn't as uncomfortable when I saw someone being critical of someone else's idea, because I thought `Nobody's being embarrassed here at all,'" says Sam Eichenfield, president and CEO of FINOVA.

"I noticed that if someone criticized an idea of mine, I didn't get emotional about it," says the Hughes Aircraft manager. "I guess when you are face-to-face and everyone hears the boss say, `You are wrong,' it's a slap to you, not necessarily to the idea."

Despite the safe haven it provides for most participants, GSS isn't always comfortable for the leader of a project or enterprise. Sometimes it takes courage for a manager to deal with the issues that surface in an anonymous meeting. It's hard to learn to deal with unpleasant input, but if problems lie buried for too long, they may become intractable. In a rare incident, the founder of a very successful medical technology firm called together key personnel from multiple levels in the organization for an GSS session. Thirty minutes into the meeting he turned red in the face and stood up. Pounding a fist on his PC for emphasis, he shouted, "I want to know who put in the comment on the problem with the interface for the new system. We're not leaving this room until I know who made that statement?" He glared around the room waiting for a response. Everyone greeted his outburst with silence. After a week's reflection he returned sheepishly to the group and said, "I had no idea there was trouble. I guess I'm more out of touch than I ought to be. Let's try again."

Anonymity helps to separate ideas from the politics behind them. Ideas can be weighted on their merits rather than on their source. Each member of a team tends to view problems from his or her own perspective, often to the detriment of the project or enterprise. For example, in traditional meetings engineers see engineering solutions, sales people see marketing solutions, and production people see manufacturing solutions. In discussion and exchange of ideas anonymously from many different viewpoints, the big picture is more likely to emerge. GSS groups often achieve a unified, shared vision of problems and solutions -- something that's difficult with traditional meeting methods.

### 2.1.6 GSS and Productivity.

Most of the early GSS work focused on improving the productivity of face-to-face collaboration because the dynamics of traditional group work were already well understood and the problems were only too clear. The first field trials of GSS took place at the Owego, NY plant of IBM Corporation in 1986 [33]. In a year-long study 30 groups used GroupSystems to solve problems in production-line quality. Teams using the technology saved an average of 50% in labor costs over conventional methods. They also reduced the elapsed time from the beginning to the end of their projects by an average of 91%. The results were so dramatic that they were suspected of being anomalous, a fluke of the circumstances surrounding the study, so a second year-long study was conducted at six other IBM sites, each with a different set of business problems. In the second study, which tracked more than 50 groups, average labor costs were reduced by 55% and elapsed 0

times for projects of all types were reduced an average of 90% [33].

In 1991 Boeing Corporation ran an independent study to determine whether there was a good business case for the use of Group Support Systems [66]. Over the course of a year they carefully tracked the results of 64 groups. The groups used GSS for problem definition, alternative generation and evaluation, implementation planning, and documentation of group outcomes. The result was an average labor saving of 71% and an average reduction of elapsed times for projects of 91%. A conservative evaluation of the return on investment for the pilot project was 170% the first year [66].

Besides finding quantitative benefits, the IBM and Boeing studies documented improvements in the quality of results and the satisfaction levels of the participants. Since these studies, other organizations have conducted independent evaluations of the benefits of Group Support Systems. The U.S. Army reported back to researchers at Arizona a total savings of $1 million in eight 1-week sessions to design a new Army-wide personnel tracking system. BellCore found a 66% reduction in labor costs for teams using the technology. The Army National Guard saved over 70% in labor costs and 90% in project elapsed time over three information systems documentation writing projects [53].

#### 2.1.7 Lessons yet to be learned about GSS in Organizations.

While the Boeing case [33] illustrates a financial success using Group Support Systems, it also illustrates some of the organizational difficulties associated with implementing new technologies. By the end of the pilot project Boeing had documented seven-figure bottom-line benefits. Estimates of the ROI for the project rose to more than 600% during the second year. However, about that time Boeing's corporate structure changed. The internal consultants were re-assigned from their centralized group to a number of locations in the field. Thus no center of competence remained to support the fledgling GSS project, and so it was canceled. It was another three years before Boeing personnel began using GSS again.

A number of organizations have had difficulties maintaining a center of GSS competence for a very different reason. As people begin to use GSS to make those around them more productive, their value and visibility rise rapidly, and they are often quickly promoted, leaving nobody with the skills to run the Group Support System. One solution to the problem is to make sure that there are always several apprentice facilitators in training so that a promotion doesn't strip the company of its GSS expertise. One general in the Marine Corps, however adopted quite a different strategy. He insisted on being the first person trained with the GSS and ran all the early meetings himself. He reasoned that nobody would be able to claim GSS was too hard to learn. "After all," he quipped, "If the general can do it, anybody can do it." Others in his command soon acquired the skills, and GSS expertise spread throughout his organization. Minor changes in personnel could therefore not disrupt or terminate the use of GSS.

### *2.2 Cross Cultural and Multicultural Issues*

The interaction and influence of culture [38] in terms of patterned ways of thinking, feeling, and reacting with the use of GroupSystems for various tasks in international contexts is an emerging area of study. Hofestede applied the concept of *Power Distance* to explain behavior patterns within different national cultures. Because distributed GSS has the potential to make multi-cultural meetings more common, researchers have begun to explore the implications of technology mediated cross-cultural collaboration. In addition, most early GSS research used lab or field groups from North American or Western European countries. More recent research has acknowledged the expanding use of GSS around the world and explored behaviors and attitudes of GSS participants from other cultures.

[TABLE 3 ABOUT HERE]

#### .2.1 Lessons from the lab.

Participants from cross-cultural and multicultural groups are able to work effectively together with a group dynamic uncommon in traditional groups. The ability of GroupSystems to minimize process losses and maximize process gains [78] enables diverse groups to participate effectively and efficiently in collaborative activities with high levels of personal satisfaction.

Cross-cultural meetings introduce the problem of participants having different native languages. Participants in cross-cultural sessions can be successfully supported even when all participants are not using the same language. The ability of GroupSystems to enable participants to contribute in their language of choice and have time to independently interpret the input of others and/or benefit from a centrally based translator enables an electronic conversation to be sustained when it would be impossible under traditional circumstances. Preliminary development work at Arizona suggests potential for building automatic translation into future GSSs.

Griffith [32] suggests that cultural differences will contribute to differences in satisfaction at the implementation of GSS technologies with high power distance cultures being more resistant to change. In addition, Griffith found generational differences in use of a GSS in problem solving tasks with Bulgarian meeting participants. She hypothesized the difference was due to the changing political climate in Bulgaria with younger participants more acculturated to challenging established norms.

Groups that do not exhibit characteristics of those in real organizations tend to yield results that are not generalizable [31]. It is often tempting to use student peer groups without a past or a future and expect them to assume roles and participate in group sessions emulating those that might occur in field contexts. Such is not the case. It is especially important when using student subjects to use relevant tasks and established relationships whenever possible.

### 2.2.2 Lessons from the field.

GroupSystems is currently in use on all continents except Antarctica. Interestingly, cross-cultural use of GroupSystems is more notable for similarities than differences, especially for idea generation. Groups world-wide tend to use GroupSystems in a fundamentally similar fashion to US groups. In part, this may be a function of limited exposure and lack of opportunity to develop unique fashions of use. In many countries, however, GroupSystems has been in use for over five years which seems sufficient time for significant differences in use to surface.

Those differences in cross-cultural use that do exist occur primarily in convergent activities. Here we find that cultures have different patterns of interaction. For example, group from countries with a high power difference, i.e., those with highly stratified and differentiated organizational and societal levels tend to prefer a more identified and slower approach to convergence than do countries with a lower power distance [82].

Although GroupSystems is being used in a variety of international contexts and associated cultures, very little use exists in practice for multicultural teams. For the most part, working sessions are being run with culturally homogeneous teams, relatively speaking. This can be expected to change as more organizations become globally focused and increasingly use GroupSystems in a geographically distributed fashion.

### 2.2.3 Lessons yet to be learned about Cross-cultural and Multicultural GSS .

Although GroupSystems is currently being widely used in international contexts, little experience exists on longer term projects that will provide insight into aspects of global impact. This extended use is expected to emerge especially as organizations engage in electronic commerce and recognize the need and benefits from providing interactive support for groups in these contexts. The stage is set but data remains to be collected.

Experience from the general use of GroupSystems with geographically and temporally distributed groups, both in cross-cultural and multicultural contexts, remains to be documented. International GroupSystems use to date has been primarily face-to-face. We expect to learn much as these distributed groups become increasingly commonplace in terms of issues such as facilitation and technological substitution of audio and visual cues.

In keeping with the extended needs of cross-cultural and multicultural group needs in global contexts, GroupSystems integrated with video conferencing is a special form of use that can be expected to emerge. Virtually nothing is known to date, for example, in terms of need for video resolution as a function of availability of GroupSystems features. The combined use of video and GroupSystems in compelling but unproved in terms of group and organizational benefits.

## *2.3 Lessons about GSS Application Software.*

The core of the group support system environment is the collaborative software component. The collaborative software developed at Arizona is GroupSystems™ . Over the years, through six generations of GroupSystems development, we have learned a number of lessons about what is important for successful EMS software in terms of structure, use, and interface.

[TABLE 4 ABOUT HERE]

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### 2.3.1 The values of modularity.

It turns out to be very useful to build EMS software into a collection of special purpose modules rather than using a single module. For example, it is possible to build a single tool that can be used for idea generation, idea organization, idea evaluation (polling), and idea exploration. By building toolkits, rather than indivisible systems to support an entire task such as strategic planning, increases the potential for tool reuse for a variety of tasks – including new unanticipated tasks [57]. New collaborative tools should take advantage of recent advances in distributed object architectures and make use of reusable distributed components [60]

### 2.3.2 Interface choices affect group dynamics.

Subtle difference in user interfaces can make large differences in group dynamics. For instance, an idea generation tool with a five line limit per comment submission encourages concise expression of ideas and enables the group to quickly explore a broad range of ideas. On the other hand, an idea generation tool that permits long comments about a few items will encourage in-depth examination of issues. Because interface choices affect group dynamics, and because group dynamics are a critical concern for group productivity, it is useful to build separate interface, each to support a particular dynamic [68].

### 2.3.3 Keep the user learning curve short.

Another reason for building separate modules is that group interfaces must be kept very simple [12]. Group members must talk, listen, think, and remember what has been said. Doing any of these things limits the ability to do the others well. If the computer interface poses an additional distraction it will hurt rather than help group productivity. Individuals have only a limited amount of cognitive effort to expend; the more effort they spend on understanding the user interface the less effort they will be able to spend on the task at hand [9]. In the EMS development effort we attempted to create tools that would permit groups to begin productive work with less than 30 seconds of instructions [19]. Participants are often able to begin work with no instructions at all. Interestingly, we accomplished the short participant learning curve by off-loading much of the complexity onto the facilitator. However, we found over time that lengthy facilitator learning curves have been an impedance towards large scale adoption of GSS tools. We are now looking to solutions which will also shorten the facilitator learning curve.

### 2.3.4 Provide both structure and flexibility.

Successful meetings require both *structure* in the group's approach to its task and *flexibility* in adjusting its approach as new information is introduced during the course of the meeting. Group support systems software must provide for both faces of this paradox.

Structured techniques, the designed mapping of group processes and group interactions towards a desired outcome, provide a road map to efficiently and effectively guide a group. Group support systems support the use of structured techniques for the conduct of meetings by providing synergy through a combination of rapid communication and structured analysis resulting in focused discussions enabling all participants to contribute their knowledge and opinions in a minimum amount of time [21].

The design of the group support systems software can enhance this contribution. Electronic Brainstorming, for example, inhibits participants from thinking deeply by limiting comment contributions to five lines. Activity Modeler helps participants push details downward by restricting the number of ICOMs to six per level of the tree [19].

Group support systems software provides the functionality of pre-planning a meeting agenda mapping each group task to a specific set of software tools. This pre-session task mapping has been found to be helpful in itself as it forces the group to think through its meeting objectives more closely than it might have otherwise. Several meeting leaders have reported that pre-session agenda building has improved their meetings [20, 50].

On the other hand, the group support system must provide for the ability to change the agenda on the fly should the flow of the meeting require such action. The toolkit structure of a group support system supports the flexibility to alter a meeting process in midstream and switch to a different tool. The GSS toolkit should have a *shift* function embedded in it to support moving data from one tool to another in real-time.

### 2.3.5 Data Portability.

When building an EMS in modules it is also critical that the designer provide a simple and seamless way to move group information from one module to the next. For example, if a group spends time generating a broad set of ideas and then wants to evaluate which ideas are best, it must be easy to move the ideas to the voting module without undue effort. Long or awkward transitions between modules will disrupt the group dynamics and ultimately doom group processes to chaos.

Even when people are working as a group, there are still pieces of the work that will be done by individual members at their own desks. It is therefore desirable to integrate group productivity tools with individual productivity tools wherever possible. It is useful to be able to move information to and from spreadsheets, text editors, data bases, and other individual productivity applications.

### 2.3.6 Lessons yet to be learned about GSS Application Design.

The movement of GSS into distributed environments opens a vast array of new research opportunities and demands. As shared distributed workspaces will more and more be occupied by multiple synchronous computer users, GSS researchers need to join with the HCI community to develop truly collaborative user interfaces which seamlessly support concerted work. Much of that support will be through multimedia and VR extensions to collaborative interfaces. Researchers must investigate along with colleagues from Communication which non-verbal behaviors are key to computer-supported concerted work and then learn to embed those non-verbal cues into the software.

Related to this is the challenge of building of extending VR environments to become GSS tools. Most early VR environments contain minimal task and process structuring; they are simply open-ended conversational spaces. GSS researchers must work with VR developers to embed GSS task and process structures into these environments.

## *2.4 Collaborative Writing .*

Significant literature exists describing the way collaborative groups write using conventional single user technology [65]. These collaborative groups tend to be small (two or three members) and tend to work independently combining their work in an editing stage. Over two dozen computer-based group editing tools have been developed in the past decade. Sharples et al. [88] identify three categories of group editing processes.

- **Sequential editing**. Sequential group writing is where the collaborators divide up the task so that the output of one stage is passed to the next writer for individual work. Editors which support this process are called markup tools. Examples of these include ForComment, as well as recent extensions to popular word processing program such as Microsoft Word and Lotus WordPro.
- **Parallel editing**. Parallel group writing is where the collaborators divide up the task so that each writer is working on a different part of the document at the same time and then the document is reassembled in an integration stage. Examples of these are Quilt, SharedBook, ShrEdit [59], and GroupSystems GroupWriter [53].
- **Reciprocal editing**. Reciprocal writing is where the collaborators work together to create a common document, mutually adjusting their activities in real time to take into account each other's edits. One example of such an editor is MULE.

Several group editors have been developed by GSS researchers but little literature exists suggesting how these editors might be used to support the creation of large documents by large groups. [58] used the ShrEdit text editor to support groups engaging in the task of designing a post office. However, this task is essentially an alternative generation and evaluation task rather than a documentation task. While they found that groups using their text editor generated longer recommendation documents than groups using paper, pencil and whiteboard technologies, they found no difference in recommendation quality or in group satisfaction. And other research collaborative writing systems are beginning to appear in the literature such as SEPIA [34], Flexible Diff [54]. Our work at Arizona has included MULE, GroupSystems V GroupWriter, and now a Windows-based GroupWriter [53]. We have supported over a dozen groups doing synchronous collaborative writing ranging in size from five to fourteen. We have supported the creation of documents from several hundred words to over 150 pages. From this work several lessons have emerged.

### 2.4.1 Collaborative writing can lead to significant productivity gains.

We have supported group which have achieved significant productivity gains through use of a computer-supported collaborative writing process. The gains seem to derive from multiple causes. First, the technology itself – when implemented in a tightly structured process – can increase the productiviity of a team of authors by allowing all of them to be writing at the same time. While this may improve the overall productivity of the group, the gains will be minimal because of the time it takes for each author to read and discuss other authors' work. Second, the act of bringing multiple authors together for synchronous writing can greatly improve the time to completion of a collaborative writing project. Much of the time normally spent during a collaborative writing effort is spent by sending drafts out for review and waiting for the review to come back. Further, when each author individually reviews a draft, there is little ability to communicate, negotiate, and resolve issues. Often multiple review passes are required before an issue is resolved - if ever.

For example, one federal government agency team was working at updating a 150 page regulation document and tasked the project to a technical writer. That writer had traveled the country interviewing appropriate team members for input to update the document. After interviews the writer then authored a draft and sent it out for comment. Several team members disagreed with key sections of the draft. Further, specialists in D.C. overseeing the process had the writer insert text to meet their needs, which team members strongly disagreed with. Eight months into the project the team met face to face for a one day meeting but were unable to come to any resolution towards the content of disputed sections of the document. Another draft was attempted, but met with little support or enthusiasm from team members.

[TABLE 5 ABOUT HERE]

Fourteen key members of the team were brought into a synchronous GSS collaborative writing session one year into the arduous process. Cliques had formed among team members with shared interests. There was minimal trust of the specialists from D. C. Using a GSS, this team produced a penultimate document in three and one half days of work. While after the session the team estimated that in a facilitated process without collaborative technology they would have required about ten days of work to create the document, in reality the three and one half days can be measured against the 365 days previously spent.

### 2.4.2 Buy-in to the content of the document increases.

In addition to gains in productivity, we have noticed significant gains in buy-in to the final group product. In the federal agency session discussed above, the group -- which had been bitterly conflicted prior to the session – felt such a strong degree of ownership towards their final document that they decided to, as a group on their last day of work, draw a cover design for the document.

Another team of four collaborative authors representing seven conflicted organization board members trying to write an organizational constitution and by-laws met for an eight hour marathon session one afternoon and evening. Their buy-in to the final document was so strong that in the end these four authors decided to vote as a bloc when the document was presented back to the full board so that the other three would be unable to amend their work. While this action was not necessarily organizationally functional, it does demonstrate the high level of shared buy-in the authoring team achieved.

### 2.4.3 An appropriate task process is vital to the success of the writing project.

Early attempts at collaborative writing at Arizona used an unstructured process where participants sat together in a GSS room and began to contribute to a document at will. This lack of structure was quickly found to be dysfunctional and frustrating for the participants. Over time from several sessions of work a multistage process emerged to support the evolution of a document. The productivity and attitudinal gains noted above emerged from groups using structured processes.

The process grows out of the collaborative writing stage models already in the literature [26, 65] with proscriptive GSS interventions at each stage. The model which evolved at Arizona contains six stages:

**1. Open discussion** - develop the objectives and general scope of the document using brainstorming or parallel discussion software to support this process.

**2. Generation of document outline** - develop main sections and subsections that will provide the structure for the document using a group outlining tool.

**3. Discussion of content within outline** - interactive generation and discussion of document content in each section using parallel discussions in a group outlining tool.

**4. Composing by sub-teams** - these sub-teams may consist of a few people or in some cases may be only one person. The task is to take the content entries from a section and organize, edit and complete the section as a first draft version using a collaborative writing tool with the data from stage three having been imported from the group outlining tool.

**5. On-line feedback and discussion** - using either a collaborative annotation tool or a parallel discussion tool, the team will review each section and make suggestions in the form of annotations or comments. The section editors will accept, reject or merge the suggestions to improve their own sections.

**6. Verbal walkthrough** - using the collaborative writing tool, the team will do a verbal walkthrough of the document.

Stages one to three are sequential in nature and only undertaken once. Stages four to six are circular in nature and in some cases multiple loops are used before the document is in final form. Minimal time and energy is spent on formatting the document. As synchronous group time may be limited and valuable, it is used as much as possible toward adding and refining document content. Formatting can be accomplished after the fact by team members or an outside editor.

It is important to stress the key lesson here is that GSS technology alone is insufficient to improve the collaborative writing process. However, GSS technology when combined with a tight task and process structure can lead to significant gains.

### 2.4.4 Addressing interpersonal issues.

Disputes often arise during collaborative writing sessions. The process described above helps to identify, focus, and structure disputes so that they can be resolved. Often disputes arise from team members having incorrect or incomplete information. Occasionally, disputes arise because different team members have different philosophical approaches to an issue. To address this and to avoid pulling the entire team off track, we have placed disputing team members together on sub-teams. We have found that this enables them to negotiate out their differences without an audience to showboat for and to compromise without losing face. When such a sub-team returns to the group with compromise text, the group has readily accepted it knowing that multiple points of view went into the composition of it.

Similar to this, when individuals bog down the group process during structured walkthroughs by attempting to wordsmith large sections of the document, we have taken to assigning those individuals to ad-hoc sub-teams with the assignment to wordsmith and report their results back to the full group. This provides them the opportunity to craft a document section they care about while allowing the rest of the group to proceed unhindered. When the group suspects that a wordsmith has a particular content axe to grind, we have assigned other individuals to the ad hoc sub-team whom we knew would keep the wordsmith in line.

### 2.4.5 Lessons yet to be learned about Collaborative Writing.

Most of our synchronous collaborative writing work to date has been within one meeting room. We, and other researchers, have little to no experience yet at supporting synchronous distributed collaborative writing. As the structured walkthrough stages, in particular, require heavy verbal and non-verbal interaction, it is currently unclear how we might replicate this work in a distributed setting.

One important measure of the success of collaborative writing is the quality of the finished document. Document quality is very subjective and difficult to measure. While we have made stabs at measuring perceived document quality, we have not found an appropriate way to measure direct quality. We believe that GSS collaborative writing can improve document quality, but to date only have very limited perceived quality measures to support this assertion.

## *2.5 Lessons about Electronic Polling*

Researchers have, for many decades, examined ways to use computers to assist groups in decision-making processes. [40, 42, 43, 46, 47, 48, 63, 72, 73, 74] However, early attempts at linking computer technology with a group process, such as MacKinnon's [46]use of an off-line FORTRAN batch process to compile votes, might be perhaps be best labeled as premature. Their failure was not on the part of their algorithms or their concepts but rather with the lack of synergy in the human-computer interaction. Even to this day, the central problem remains enhancing the group process so that members' outputs, in real-time and naturally, become inputs for computer processes and vice versa [3]. However, isolated successes [77] presage the great potential for computer-based analytical tools to assist groups in arriving at a better understanding of the problem and to generate new and synergistic options for action.

The literature on voting and social choice has long attained maturity and many of its lessons can be realized in Electronic Voting. Consider, for example, Arrow's [2] classic *impossibility theorem* which shows that there is no fair way of forming a group ranking from a set of individual rankings. However, with the advent of networked computers and their algorithms which provide real-time access to informational databases, support for pre- and post-decision group discussions, immediate feedback, and tools to fully analyze the decision process, Electronic Voting is only now emerging as a separate research stream, one with neoteric lessons absent from the classic literature.

In most cases electronic voting tools play a very different role from those of conventional voice or paper-ballot methods of voting. Traditional Voting usually happens at the end of a discussion, to close and decide a matter once and for all [40, 37, 51]. Electronic Voting, however, tends to inspire a "vote early, vote often" mentality within decision groups. Because it is fast and meets the usual GSS criteria of preserving anonymity, granting equal treatment to members, and mitigating the effects of irrelevant influences, teams may use Electronic Voting to measure consensus and focus subsequent discussion, rather than to close debate [3]. In these ways, the technology is more accurately described as polling than as voting. While it can shorten discussions, saving time is not the only reason to use electronic polling tools. Teams find that polling clarifies communication, focuses discussion, reveals patterns of consensus, and stimulates thinking [83, 62].

[TABLE 6 ABOUT HERE]

The following case studies, taken from confidential research of actual events, illustrate the diversity of benefits organizations can derive using electronic voting.

### 2.5.1 Confidence voting.

A management crisis loomed for a major telecommunications company. For six months, 39 senior managers had wrangled to come up with an ordered ranking of 89 technical researchers on the company's payroll. When they finally completed this arduous task, a new vice president rejected the process by which they had achieved their results. This vice president didn't believe that the results accurately reflected the technical researchers' qualifications.

The new vice president's reaction isn't all that surprising. Rank ordering gives rise to an ordinal scale. In the strictest propriety the ordinary statistics involving means and standard deviations ought not to be used with ordinal scales, for even these simple statistics imply a knowledge of something more than the relative order of data [70]. When only the rank order of data is known, we should proceed cautiously with our statistics, and especially with the conclusions we draw from them [70]. Simply put, the new vice president recognized that group members had opinions that extended well beyond the ordered ranking and desired a method that allows a fuller expression of those opinions.

An outside consultant was hired to engineer a new computer-supported voting process. The new scheme required each participant to submit both a ranking of each researcher and a measure of how strongly they felt about the ranking they were giving. The senior managers then reviewed several different graphical analyses of their votes and found much confidence and consensus on some of the rankings, and a great deal of variation on others.

Subsequent discussion revealed that many managers did not know some of the people they were ranking, relying instead on second-hand information and public opinion. After much discussion and information sharing the group voted again, this time with a much stronger consensus. After the second vote the group discussed their remaining differences and in short order arrived at an overall ranking of their technical staff that all participants could live with. They agreed that the new computer-supported voting process was much more efficient than traditional voting methods and inspired a more open and focused exchange of ideas. More importantly, everyone from the vice president down felt that the new rankings were more legitimate than those obtained from the earlier process. The confidence-weighted votes and graphical representations of voting patterns provided managers with a larger picture than they had previously seen.

Weighting methods have been tested in a variety of non electronic contexts and have seldom been found to perform much better than equal weighting as a means of improving group performance[16, 17, 75]. However, as with the current case, many GSS-supported voting experiments have found that weights improve the efficacy of the decision method [4, 40]. As Ferrell [27] points out, it may be that weighting methods have not been tested in those situations and environments where they can be especially effective.

### 2.5.2 Getting past violent agreement.

Sometimes members of a team will vigorously debate issues upon which they actually agree. A startling example of this phenomenon of unneeded debate occurred in a health care organization that encompassed a dozen hospitals throughout a major metropolitan area. Three interest groups -- doctors, administrators, and directors -- set out to define a mission statement and to decide how various special services should be distributed among the hospitals. For reasons that were unclear, the process degenerated into an acrimonious battle -- at which point someone noted that it had been three years since the groups had met without their attorneys being present.

The groups decided that electronic polling might be helpful in locating the source of the conflict, and decided to perform an experiment. Approximately 200 people attended a meeting where every participant was given a hand-held, radio-linked voting box. Using a large public screen, a facilitator displayed a number of policy statements such as, "When patients need emergency care it shall be given without reservation, without reservation, regardless of ability to pay." Participants voted by agreeing or disagreeing with each statement as it was displayed.

Prior to the meeting, it was assumed throughout the health care organization that doctors, as a group, were responsible for obstructing agreement and thus progress. The prevailing wisdom was that hospital administrators and directors were the peacemakers in the group, and that a good deal of their energy went into persuading the physicians to be less intractable. This assumption was destroyed by the results. Analysis of the votes by subgroups revealed that, contrary to everyone's expectations, doctors and directors were in nearly perfect agreement on every issue. It was actually the staff administrators who were out of step, although for three years the administrators had been telling the directors that the doctors were causing problems.

A parallel situation occurred at a board meeting of a major non-profit organization. As their group of 12 executives prepared a five-year strategic plan using a GSS, they reviewed funding for each activity supported by the organization. One such activity involved the broadcasting of public service announcements (PSAs). For years, PSAs represented the highest expenditure not directly providing a service to the organizations' constituents. However, their role in educating the public had been held sacred. In an Approval Voting exercise [5, 6] the group indicated which activities, in their opinion, were worthy of further funding. To everyone's surprise, <u>none</u> of the 12 executives felt that PSA's deserved funding. In the ensuing discussion, it was revealed that each executive assumed that only they had a minority position. It was further learned that this situation had existed for many years on this issue - and others.

### 2.5.3 Maximizing knowledge use when voting.

Sometimes people do not think to share critical information until they are puzzling over the spread of electronic votes. Traditional methods of measuring consensus that do not reveal group thinking patterns can prove costly. The head of a mining company used a computerized voting system for the highly charged political task of allocating a budget across multiple corporate sites and projects. He asked a number of key executives for their opinions, but the results of the first poll were widely scattered. No one seemed to agree on budget priorities.

The president pressed his executives in order to understand why their voting patterns were so dissimilar, given that they all presumably had the good of the corporation in mind. Finally, one vice president ventured, "None of us really knows what goes on at all these places. We can't really make an informed recommendation." The president then arranged to have electronic comment cards included on the ballot, and advised the group, "If you know about a project, type in what you know. If you don't know, read what the others have typed." Within half an hour, the group had exchanged a great deal of information about the various projects and sites, and the subsequent vote-and-discuss cycle resulted in high consensus on the budget allocation. As the team left the room, one of the vice presidents pointed at an item on the bottom of the budget priority list, and commented ruefully, "we dumped $5 million dollars into that turkey last year." An eager champion had pushed the project, and when no one had information to dispute his arguments, the management council had simply taken a chance.

### 2.5.4 No more Mr. Nice-guy.

Electronic polling can sometimes facilitate decisions that are too painful to arrive at using traditional methods. A corporation with a particularly difficult budget crunch chose to use an electronic polling system to help decide how best to downsize. In many previous meetings, the possibility of eliminating a large but ineffective division was raised but was set aside for fear of offending the division's head, who was a very personable and effective lobbyist for his employees. Although the division was generally unproductive, no one wanted to hurt the manager's feelings by pushing to have the division eliminated. Instead, using traditional voting methods, the group consensus indicated that across-the-board cuts should be implemented. Everyone would bleed a little, sacrificing some efficiency in the interests of harmony.

When the electronic votes were tallied, however, it was clear to all involved that the most sensible and most widely supported alternative was to eliminate the ineffective division. In doing so the organization did not have to make potentially crippling cuts to mission-critical functions, and at the same time it distributed responsibility for the decision among the participants.

#### 2.5.5 Limits on electronic voting.

Not all electronic voting sessions are successful. Occasionally, when all the votes are in, all the terms are defined, and all the hidden assumptions have surfaced, it turns out there are fundamental and irreconcilable disagreements between parties.

A savings and loan company faced a crisis that threatened its survival. During most of the discussion people were optimistic that they would reach a consensus and proceed accordingly. Rather than converging, however, group members views diverged as electronic voting proceeded. An analysis revealed that the group was, in fact, made up of several factions with mutually exclusive, deeply held positions. The session came to an end with an agreement to disagree. The only thing the participants knew was that in light of the bitter disagreements they had uncovered, the viability of the current management team, and thus the company, was at stake. On the bright side, the team was now focused on the difficult problem, rather than wasting time squabbling about minor disagreements.

#### 2.5.7 Lessons yet to be learned about electronic polling.

In addition to making face-to-face meetings more productive, electronic voting plays a critical role in supporting geographically dispersed meetings. Remote meeting participants lack such nonverbal cues as shifting gazes, body positions, and gestures that let speakers sense it's time for a discussion to move on.

Although many teams save time and money with electronic voting, it would be a mistake to view that as the technology's main advantage. Some groups spend more time on their deliberations when using electronic voting than with traditional methods. Research has shown that groups using structured voting schemes and response analyses to clarify communication and focus discussion consistently reach higher-quality decisions than groups using traditional voting methods [4]. Electronic tools that permit any participant to change his or her vote at any time and provide a real-time display of group voting patterns, establish a different dynamic by indicating shifts in consensus. New network-based voting schemes permit a group to begin interacting long before participants arrive in the meeting room, and to extend interaction after the face-to-face meeting is over.

### *2.6 Lessons about the GSS Facilities and Room Design*

The importance of the physical environment to the process and outcomes of technology supported meetings has been reported in the GSS literature by several authors [56, 58, 59, 81]. GSS facilities range from the Spartan to opulent, from the inexpensive to the extravagant. An electronic meeting room need not be expensive to be successful, but we have learned from our experience designing and using technology-supported meeting facilities that fundamental design considerations can enhance the impact of the technology on the meeting process.

[TABLE 7 ABOUT HERE]

#### 2.6.1 The public screen.

Most GSS facilities include one or more public screens. A public screen is a way to give the group a common focal point, as well as a way to share public information. [44]. When more than one screen is available, facilitators use the second screen to support electronic slide shows, provide a group view of a participant screen, display two different views of shared information, or bring an external document into public view. Multiple public screens displaying a single image may also serve to improve viewing angles and shorten viewing distance for meeting participants.

### 2.6.2 Lighting is critical.

The quantity and quality of lighting significantly impact both performance and satisfaction of workers [36, 79, 84]. The introduction of computer technology complicates the delivery of appropriate lighting [1, 64]. It is difficult to strike a balance between adequate lighting and the need to view a public screen . Standard office and conference space buildouts often include only fluorescent lighting, which washes out a front projected display. Optimal technology-supported meeting facility lighting balances the need for a clear bright public display with adequate workstation task lighting. And these two needs must be considered independent of the delivery of ambient lighting. The variety of tasks which occur during group support systems sessions require multiple coordinated lighting systems in the room. There are several decisions meeting room designers can make to provide for better lighting:

- Use indirect rather than direct systems to minimize glare;
- Provide individual task lights with parabolic louvers;
- Use dark matte surfaces on counter tops to reduce glare;
- Provide rheostat controls for variable dimming;
- Provide easy-to-use presets for the meeting leader.

Lighting is not only an environmental hygiene consideration. Lighting can also be used by a meeting facilitator to focus group attention, impact group mood or energy, and communicate acceptable norms of group behavior. We often use lighting levels to non-verbally signal to a group when it is time to focus on their computer screens and when it is time to communicate verbally.

### 2.6.3 *Seating configuration.*

The first GSS facilities arranged participants on three sides of a rectangle with the public display at the open end.. This configuration allows for the participants to have reasonably good line of sight to other participants as well as to the public display screen at the open end of the horseshoe. It also allows the facilitator to step into the middle of the horseshoe to gain the attention of the group. Several other configuration have been systematically tested in other classroom and GSS facilities with varying results [44, 45, 71].

Many GSS providers have been built facilities in the original three sides of a rectangle arrangement. This focuses group attention quite well, but does not allow for very large groups. Once the rectangular table seats more than 16 participants, the distance between individual participants exceeds a distance affording comfortable verbal conversation. Further, many participants will not have direct line of sight with other participants. Other facilities have made use of a round table with participants on every side. Again this focuses group attention well, but requires some participants to sit with their backs to the public screen and limits effective group size to about 12.. Still other facilities have been designed as tiered auditoria. These facilities provide excellent focus towards a public screen, but provide poor within group focus. . All seating configurations result in tradeoffs [28, 64]. It is important to consider the primary purposes of the facility and to decide the relative importance of group focus, public display screen access and support for large group size.

### 2.6.4 *Lines of sight and the work surface.*

Some consideration must be given to the configuration of the work surface that will be made available to the participants. They must be able to see their computer screen clearly, and they must also be able to see one another clearly. Some electronic meeting rooms have the CPUs sitting on desktops, and the monitors sitting on the CPUs resulting in a "Kilroy" effect. People strain to see over and around the technology. In this setting people tend not to engage in the proceedings; they lose interest and participation drops. Ideally monitors can be partially recessed into the desktop so people have clear lines-of-site to one another. Some room designers have completely buried the monitors under a glass panel in the desktop, completely uncluttering the surface. This approach turns out to be a mixed blessing because lights and windows create glare on the glass. Further, if this solution is chosen, care must be taken so that shorter meeting participants have a clear line of sight to the embedded monitor once they pull out their keyboard drawer for use.

It can also be difficult to keep the monitor viewing area free of papers and clutter during the meeting. The partially-embedded monitor turns out to be a good compromise [49].

Along with space for the monitor, the work area must provide room for participants to spread out at least two full-sized legal sheets of paper. Despite good intentions of providing for paperless meetings, participants often need to work from documents while interacting in an electronic meeting room. We have been designing millwork to provide for at least eleven inches between the front on the workstation and the base of the monitor to afford the ability to place a sheet of paper in front of the participant. And by adequately spacing monitors apart each participant is afforded a small amount of visual privacy so that participants are less likely to view anonymous contributions typed in by other participants.

### 2.6.5 *Social space.*

It is often important to provide social space along with the work space in an technology-supported meeting facility [52, 64]. We have built technology-supported meeting facilities to support GSS meetings of full day or several days duration. When a meeting will last longer than one-half day, consideration must be given to supporting both group process needs and individual needs. Most facilitators will use a variety of group process techniques during a lengthy meeting to keep a group fresh and focused. Facilitators may wish to break the group into sub-groups or into individual assignments from time to time. The physical environment must afford such a variety of group dynamics. Further, groups will take breaks. The physical environment should afford caucuses the ability to hold private informal conversations during those breaks. Group forming, storming, and norming activities often take place during such informal interactions. Informal negotiation and caucusing can often lead to breakthroughs difficult to achieve during a formal meeting protocol. The physical environment can support this by providing cozy nests, nooks and crannies to afford private conversation. The physical environment can further afford this by providing white noise for acoustical privacy. One facility at Arizona affords this sort of informal communication by the placement of an outdoor fountain just outside the meeting room. The running water provides a white noise which ensures acoustical privacy for small groups engaging in conversation or negotiation during breaks [55].

Individual needs can be supported by providing easy access to food, drink, and rest rooms, In addition, individual needs can be supported by providing space where individuals can retreat to reflect or meditate. Some centers afford this by including a garden with running water, foliage, and soft non-Euclidean shapes. Such space may afford both visual and acoustical privacy for individuals and small caucuses. Too often technology-supported physical environment design projects are defined to be *just* a meeting room and consequently such vital spaces are overlooked.

### 2.6.6 It is important to minimize ambient noise and provide effective HVAC control.

Motor and fans on the computers and projection equipment in the technology-supported meeting facility add both significant heat and noise to the environment. This is a concern as the quality of the ambient environment has been shown to have an impact both on performance [85,87] and workplace satisfaction [85, 86, 87]. In addition, too much heat or humidity can damage the computer equipment and dust, smoke or static electricity can damage data storage equipment.

An effective heating, ventilation, and air conditioning (HVAC) system is imperative to the success of a technology-supported meeting facility [49]. The exact amount of cooling required for a given facility will depend upon several factors including: the size of the facility; the specific equipment chosen; the amount of sunlight or other external heat sources present. Design solutions include installing a stand-alone HVAC system, using air filters in an existing system, and installing anti-static carpet. While a stand-alone HVAC system may be expensive, it affords the additional benefit of remaining functional even if the central building system is down as well as providing for finer tuning of meeting room temperature and humidity controls.

The HVAC system, whether centralized or stand-alone, may actually contribute to the ambient sound problem. HVAC systems often include fans to move air. These fans or the adjacent ductwork may produce significant ambient noise. One strategy used at Arizona to reduce this noise has been to place the HVAC returns beneath the computer millwork. Fresh cool air is dropped from the ceiling as cool air naturally falls. Vents in the millwork accept the cool air which then falls past the computer equipment and is sucked into floor ducts beneath the millwork. The heated air is removed from the environment without ever passing by the meeting participants. In addition, much of the ambient noise generated by the computers is taken along with the air.

### 2.6.6 Lessons yet to be learned about GSS Facilities and Room Design.

Much of the GSS physical environment research completed to date has been engineering in orientation. We have built different types of rooms and millwork, and then observed how participants behaved in the completed space. We have not yet engaged in the theoretical questioning of why participants behave the ways they do in technology-mediated collaborative space. While there is a rich environmental psychology literature to draw from, most of this territory is yet uncharted. The lessons of this environmental psychology work will become vital to designers of virtual GSS environments. For we cannot build VR artifacts to support information communication structures in technology-mediated space until we know how the physical artifacts impact interaction in physical space.

## *2.7 Lessons from the Facilitators and Session Leaders*

The person who chairs an electronic meeting is the leader or facilitator. This person may be the group leader, another group member, or a separate, neutral individual who is not a group member. Using a non-member enables all group members to participate actively rather than having to lose one member to serve as the chair. A non-member can be a specialist in GSS and group work, but may lack the task and group knowledge of a regular member. The meeting leader/facilitator provides four functions. First this person provides technical support by initiating and terminating specific software tools and functions, and guiding the group through the technical aspects necessary to work on the task. This reduces the amount of training required of group members by removing one level of system complexity. In some cases technical support is provided by an additional technical facilitator or technographer. Tandem facilitation can be beneficial with GSS technology as attention needs to be paid to both the group and the technology, sometimes simultaneously [8]

[TABLE 8 ABOUT HERE]

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Second, the meeting leader/facilitator chairs the meeting, maintains the agenda, and assesses the need for agenda changes. The leader may or may not take an active role in the meeting to improve group interaction by, for example, providing process structure in coordinating verbal discussions. This person also administers the group's knowledge. In an GSS designed without support for meeting leaders/facilitators, any group member may change or delete the group memory. When disagreements occur, members' competition for control can create dysfunction. While this is manageable for small collaborative groups, it is much less so for larger groups with diverse membership, where competitive political motives and vested interests exist. With GSS, members can view the group memory and add to it at their own workstations, but when desirable only the meeting leader/facilitator can modify and delete public information.

Third, the meeting leader/facilitator assists in agenda planning by working with the group and/or group leader to highlight the principal meeting objectives and develop an agenda to accomplish them. Specific GSS tools are then mapped to each activity. Finally, in an on-going organizational setting where the meeting leaders/facilitators are not group members, the meeting leader provides organizational continuity by setting ground rules for interaction, , enforcing protocols and norms, maintaining the group memory repository, and acting as champion/sponsor. The roles of the meeting leader /facilitator may also change over time. For example, after a group has some experience using GSS, the need for technical support and agenda planning advice may decrease. Through both facilitation research and organizational practice several lessons for GSS facilitators have been accumulated.

### 2.7.1 Pre-plan the Agenda Carefully.

The most basic principle for successful use of electronic meeting systems is that the task must be very obvious and salient to the group, and the activity in which its members are engaging must clearly advance them toward accomplishing that task. Where a conventional meeting may wander for three or four hours before people realize it is off track, a GSS meeting can resemble a train wreck in a small fraction of an hour if it is not well planned. If the participants believe that the technology is engaging them in irrelevant activities they will quickly grow hostile or dysfunctional and refuse to continue. [10].

The importance of pre-session planning cannot be over-emphasized [21, 50]. Prior to a GSS session, the group leader must define exactly what concrete deliverables the group will create -- be it a problem statement, a list of possible solutions, a documented decision, a plan of action, or whatever. Defining a deliverable can in itself be a difficult task, but without it an electronic meeting is likely to founder. Having defined a deliverable, the group leader and facilitator must then decide on a process for achieving the deliverable. This requires an awareness of the GSS tools and the different dynamics each can produce. Having mapped out a process for achieving the goal, the leader must also be sure that the appropriate people are invited to -- and will attend -- the meeting. Any group with a stake in the outcomes can and should be represented. With electronic meetings this is much more feasible than with conventional meetings, because GSS meetings can include may more people without hampering group productivity and GSS meetings can provide support to minimize political dysfunctions which might occur by bringing hostile groups together..

### 2.7.2 Alternate Style of Group Interactions.

One source of group fatigue is the monotony that comes from repeating the same kind of activity over and over. This work strain can be reduced if the agenda permits alternating among different interaction styles. One dimension to alternate along is electronic and oral interactions. Another dimension to alternate along is to move the participants between full group activities and smaller sub-group activities every so often. Varying the work environment in these ways reduces monotony, which in turn improves productivity. Further, varying interactions stimulates different modes of communication which may produce synergies or break logjams of conventional thinking. GSS supports according groups among different modes of interaction as the software can be used to fold together parallel work into a single group repository. In additional, GSS can provide for easy and effective ways for each sub-group to report back their work to the full group and for the full group to evaluate sub-group work.

### 2.7.3 Control of Participant Interactions.

The facilitator can affect the amount of online discussion among participants with subtle verbal cues and with switch selection choices in the GSS software. For example, if the facilitator wants participants to respond to one another then s/he can select for the GSS discussion tools to number all participant comments and s/he can provide verbal instructions to the group as to how easy it is to respond to a comment simply by referring to its number. On the other hand, if the facilitator wishes participants to focus attention at developing already present ideas and wishes to discourage cross discussion, s/he can turn comment numbering off.

### 2.7.4 Non-Verbal Communication.

It is important for the facilitator to remember that the use of electronic communication technologies does not eliminate the power of non-verbal communication in the meeting room. The facilitator must remember to be careful about delivering non-verbal cues. Position in the room, posture, eye contact, and gestures are all important parts of the guidance the facilitator provides the group. In return, the facilitator can receive significant non-verbal information from the group if attentive to the cues. For example, facilitators can learn to gauge group energy and interest in a GSS discussion session simply by listening to keyboard clicks. The noise level in the room will tell an experienced facilitator when the process is producing diminishing returns and it is time to move on to the next item on the agenda.

### 2.7.5 Verbal Communication.

Even though much of the group discussion takes place online during an GSS session, participant to participant on-line verbal communication can have a huge impact on the results of a session. For example, one cue a facilitator uses to determine whether a group is anxious or bored is the amount of humor present in online comments. When a group is focused on the topic at hand, there will be only a moderate amount of humor embedded in the conversation. Once the level of humor noticeably increases the group is ready to move on.

A facilitator can impact how conversational participant verbal input will be by implementing structure and training choices during a meeting. If the facilitator wished participants to brain dump ideas into the shared group memory s/he can structure the GSS to include many parallel topics being in discussed in tandem. If there are more than one third the number of topics as there are meeting participants, participants will have difficulty focusing on what other participants are saying and will engage primarily in dumping their own ideas into the repository. In addition, if the facilitator wants to stress interactive discussion among participants who are novices at GSS, s/he can encourage this by taking the participants through a two stage training of first submitting a comment to the discussion and then, in lock step, finding a comment and directly responding to it.

A facilitator can impact participant argument quality by probing and encouraging further development of arguments in on-line discussion [8]. Facilitators can also use the anonymity features embedded in GSS to encourage risk free exploration of position rationale and argument development. Facilitators can encourage participants to take on a devil's advocate role (or do so themselves) to push for stronger supporting constructs to arguments put forward.

Facilitator cues can have a large impact on group performance as well. One recent experiment [89] found that the facilitator could boost group performance in an idea generation task an average of 30 percent simply by changing two phrase in the instructions to the participants. Performance increased if the facilitator adopted a jocular tone and urged the participants to "kick butt" rather than to "try," and suggested the participants would be "brain-dead" instead of "below average" should their performance flag. This small example illustrates a key point: GSS meeting tools, like the tools of a craftsman, must be used with skill and understanding. The success of the technology depends both on the quality of the system and the quality of the processes in which it is used.

### 2.7.6 Lessons yet to be learned about Leadership and Facilitation

Much work remains to be done in areas of using technology to leverage facilitator productivity and facilitator knowledge in GSS sessions. For example, the expert systems tools might be introduced into the session planning process to aid facilitators in their design of meeting agendas and choice of GSS tools. Software wizards might be introduced to guide the facilitator real-time during meetings at tool selection or group process awareness. Additional tools could monitor on-line group processes and provide the facilitator with feedback on group productivity measures.

Currently GSS facilitators are trained through apprenticeship models. It can take several weeks to several months for even an experienced facilitator to become comfortable leading a GSS session. This has proved to be an inhibitor for several classes of facilitators to actively embrace GSS technology. In particular classroom instructors have been reluctant to incorporate GSS into their classroom processes because, in part, because of the heavy learning curve required. While simpler GSS facilitator interfaces will be a part of the solution, researchers much evolve methods to train facilitators more quickly.

And distributed facilitation is a largely unexplored area. As more GSSs are implemented as distributed systems, more facilitators will be called upon to lead distributed meetings. Little research has yet been undertaken to understand and improve the process of distributed facilitation. A vast amount of work is required to address this issue.

## 2.8 Lessons about GSS in the Classroom

Over the past three years a number of researchers have begun to explore the use of GSS to support learning. Early studies tended to be experimental, and focused on automating standard classroom activities. For example, instructors lectured, then posed questions to the students. All students responded simultaneously through the GSS [11, 90]. Class participation rose dramatically, and student interest increased substantially, but learning improvements were only marginal.

[TABLE 9 ABOUT HERE]

However, substantial benefits accrued when researchers began to use GSS to enable new classroom dynamics that were impossible with standard methods [91]. A series of one- and two-year-long field studies explored ways to improve learning with GSS [91, 92]

### 2.8.1 New technologies enable new pedagogies.

The successful approaches required a fundamental change in the role of the instructor. Rather than being the "sage on the stage," delivering information, the instructor became the "guide on the side," leading students through the problem-solving process and directing them toward useful information. The problems were framed such that the students perceived a vested interest in the resolution. The instructors chose problems carefully such that the students had to learn what the teachers wanted them to know in order to get what they wanted. Using the GSS the students engaged one another on-line. This left the instructor free from the podium, able to work with learners one-on-one as the class sought a solution.

At Orr Elementary School in Anacostia, Washington, D. C. [10, 92] 64 percent of the learners in this inner-city school dropped out before finishing high-school. Interviews with the learners revealed that they did not believe they would get good jobs, nor that they would be able to attend university. They were concerned about surviving the urban environment day-to-day, and they considered school to be irrelevant. The instructors reasoned that they might be able to re-engage the disaffected learners by having them work on problems the learners considered real and important. Solving real problems typically takes more time than is available in a standard classroom so are usually not an option.

However, with GSS the instructors could choose not to lecture, and implement a cooperative learning process using real and salient problems. The learners were engaged and energized to find information for themselves, in the classroom, in the library, and on-line.

For example, while one teacher wanted the students to learn letter-writing skills, she did not begin with a lecture on letter writing. Rather, she hung a poster on the wall which illustrated proper letter formats, and then asked her 22 students if they would like to try to persuade Michael Jordan, a famous athlete, to visit their school. The students jumped at the chance. The instructor guided the students through the process of solving that problem. They used electronic brainstorming to generate reasons why Michael Jordan might be persuaded to come. The instructor's writing activity showed on a public screen at the front of the room. This modeled the letter-writing process for the students. Then the instructor asked the students to draw from the same idea pool to compose individual letters to the athelete. The students enthusiastically proceeded to write.

Their first efforts were technically atrocious. The instructor, who had still not lectured on letter writing, asked the learners to evaluate how persuasive they thought their first efforts would be. The learners determined that they were not very persuasive. The instructor pointed out the letter-writing poster on the wall, and suggested that the learners help one another edit their letters. The learners worked for another hour-and-a-half kneading their letters into acceptable form. The instructor circulated to help learners who had difficulties. The instructor then wrote a cover letter and mailed the bundle to the athelete.

The students did not persuade Michael Jordan to come to their school, but subsequent efforts brought an astronaut and a Marine Corps general to their classroom for a visit. Throughout the year the learners continued to use the GSS for team and individual writing toward goals they considered important throughout the year. Their reading and writing scores advanced two grade-levels more than those of their peers in other classes.

The pedagogy in this case was radically different from the standard approach. The instructor did not deliver information. She offered problems considered important by the students, and guided the students as they sought solutions. She suggested where they find information (the poster), and helped them apply the information to their problem. The slowest learners in the class were not left behind by a fast-paced lecture. The brightest students were not held back by the slow pace of other learners. All participated fully. The new pedagogies did not depend on the GSS technology, but would have been too time consuming and unwieldy to implement without it. Therefore, GSS enabled new pedagogies that engaged at-risk learners in ways not practical under standard methods.

Researchers tested the approach described above in other case studies at the grammar school, junior high, high school, and undergraduate levels. Learners at all levels engaged successfully in the problem-based learning strategy. Their reading, writing, argumentation, problem-solving, and teamwork skills improved substantially. A number of practical lessons emerged from those efforts.

### 2.8.2 Vested Interest Motivates Cognitive Effort.

The approach described above only works when the students perceive the problem to be real and salient. GSS tools typically allow for anonymous input. When asked to work on contrived problems, learners at all levels quickly degenerate into flaming and buffoonery. *Flaming* means that the participants launch vitriolic personal attacks often accompanied by profanity and obscenity. *Buffoonery* refers to jocular off-task comments meant to disrupt or distract the group. Several strategies emerged for reducing flaming. One instructor empowered all learners to delete contributions that offended them. Another asked all students to tag their contributions with a matriculation number. This identified the learners to the teacher, but not to one another. Several teachers made an extra effort to raise the students' awareness of their vested interests in the problem. In the end, however, it became clear that the GSS was only an effective tool when the learners considered the work it supported to be valuable and salient.

### 2.8.3 The most at-risk learners can become the leaders.

The most disruptive and disengaged learners often became the leading contributors to projects they considered salient. There are several factors which may account for this. First, these were the learners who had decided school was irrelevant, and were willing to take action on their belief. When they decide the on-line activities were relevant, they may also have chosen to act on that belief. Second, these learners tended to be older than their peers, having been held back one or more grades. When they brought more developmental maturity to the tasks in which they engaged.

### 2.8.4 New Technology Can Be Tough on Teachers.

Students in these studies had no problems with the new technology. Teachers, on the other hand, faced several difficult barriers. First, teachers already have a job that demands much of their available attention, yet it often fell to them to build and maintain the computer networks upon which the technology ran. Their schools were not attuned to the need for technical support. It became clear over time that teachers don't have enough time to both run their classes and maintain networks. Long term solutions will require the functions to be separated. Systems must be configured so that teachers can bring their students into collaborative environments effortlessly.

Some teachers also faced a barrier of their own assumptions. Some found it difficult to stop thinking of themselves as information delivery specialists and start thinking of themselves as mentors to learners on a quest toward goals important to the learner. Only after they gained experience with GSS did they begin to understand that newer, more powerful roles are available to them. It is therefore important not to simply place the technology in a school and leave it. It is important during the first year that a person with a good grasp of the new pedagogies be in residence and available to help teachers plan their on-line activities.

### 2.8.5 Teacher Interfaces Must Be Simple.

It has long been the goal of GSS developers to make interfaces so simple that novice participants could begin work with less than a minute of oral instruction. One technique developers have used is to off-load much of the complexity from the participant interface to the leader interface. However, classroom teachers have more demands on their attention than do managerial facilitators. In addition to attending to the learning content, they must also monitor the cognitive development of the learners, and monitor learner deportment. Field experience revealed that teachers needed interfaces that impose substantially lower cognitive loads than do the facilitators of managerial meetings.

### 2.8.6 Lessons yet-to-be-learned about GSS in the classroom.

While early studies suggest that substantial benefit may be derived from the use of GSS in the classroom, little is known about how best to integrate the technology into the physical classroom environment. How may tables, chairs, screens, and keyboards be arranged to best support cooperative learning? What changes should be made to lights and windows? What other resources should be readily available?

It is also not entirely clear how best to assist teachers to learn to wield the newest tools in their kit. Day-long, week-long and month-long training courses have been ineffective. Only year-long partnerships between novice teachers and teachers knowledgeable about GSS have been effective. The primary difficulty teachers new to GSS experience is not with the running the technology. That they appear to learn in three or four days. It is that the teachers face a new teaching paradigm unsupported by past experience, text-books, teacher-manuals, activity books, or any other resources that would help them figure out what to do with the GSS once they have it. It is far too expensive to put trainers in every classroom for a year. New methods and approaches will have to be developed before widespread roll-out can begin.

Much remains to be learned about other possible uses for GSS in the classroom. Existing studies constitute early forays close to the frontier. As field work continues new methods and techniques may emerge.

### 2.9 Business Process Reengineering

Business Process Reengineering (BPR) and its cousin, Business Process Improvement (BPI), are often applied to the process of ascertaining how an organization can transform itself into a new form to meet the needs of the future. The University of Arizona has used GSS tools and methodologies with numerous government and private organizations over the past five years seeking to accomplish BPR/BPI.

[TABLE 10 ABOUT HERE]

### 2.9.1 GSS supports large heterogeneous re-engineering teams.

One of the most consistent lessons learned is that groups both large and small composed of members from all organizational levels can successfully accomplish BPR/BPI. The ability to use GroupSystems in combination with specially designed facilitation protocols enables diverse and often antagonistic groups to efficiently and effectively deal with the many and varied issues and complexities associated with BPR/BPI [19]. With GSS groups as large as 30 participants have been able to work effectively. These groups are much larger in size that traditional BPR/BPI facilitators can work effectively with. Large groups allow for more subject matter expertise to be considered and lead, in the end, to greater likelihood of buy-in to the proposed new processes by members of the organization. The introduction of large groups to the BPR/BPI is facilitated by parallel sub-group work at various stages of the model development process.

With large heterogeneous teams working on BPR/BPI, there is a need for summarization and integration of results across sessions and between sub-groups. It is extremely easy to develop a relatively complete product with consensus and buy-in of sub-group members in a session that does not *travel well* outside of the context of that sub-group. Further, it is also possible for the full group to develop a product that does not *travel well* to the organization as a whole. As such, opportunities for BPR/BPI can become insulated and not put into practice. Special attention needs to be given to providing briefing packages that session participants can use to promote change.

### 2.9.2 Special purpose GSS software is advisable.

BPR/BPI modeling processes require structures that do not exist in most GSS software packages. Specific tree and network structuring with rule or consistency checking is desirable. Further, graphical representation of this information is extremely helpful. Therefore, special modeling tools to assist in structuring participant input and graphically displaying results are recommended to sustain a group dynamic and facilitate the process. Without such tools, a group is not able to successfully participate in modeling, does not make maximal use of effort, or develops a "compost heap" of processes that serve neither the needs of a group nor the needs of system developers. Several special purpose tools have been built at Arizona specifically to support the BPR/BPI process.

### 2.9.3 BPR/BPI requires both facilitator and modeler roles.

The group dynamic associated with BPR/BPI is different that other group support sessions and requires a combination of modeling and facilitation knowledge. This marriage is difficult to obtain and frequently requires session support in excess of that normally supplied for group sessions. Successfully supported groups, however, develop a sense of buy-in and support that is otherwise rarely see in BPR/BPI activities [19].

It is difficult to combine modeling and facilitation techniques is a fashion that result in a defined organizational role. The key to success seems to be recognition of the intersection between modeling and facilitation roles and the establishment of a team approach to supporting groups and organizations. By so doing, self sustaining organizational support can be achieved independent of consultant assistance.

### 2.9.4 GSS can reduce the time required for model building..

Groups using GSS tools for BPR/BPI were able to fast track process models up to seven times faster than by using traditional (non-GSS) facilitated techniques. This was accomplished by using a bottom-up approach to model building. However, as it became difficult and time consuming to reconcile errors in these bottom-up models, a more traditional top-down approach was evolved which was still two to three times faster than traditional facilitated techniques [18]. Field studies have demonstrated that GSSs promote very fast data collection from subject matter experts, but these subject matter experts require significant facilitative help at organizing relationships among the data elements [41].

Related to this, one unanticipated benefit has emerged during field studies. As non-GSS BPR/BPI session often lasted eight weeks at a particular government agency, managers often sent less vital or less proficient staff to be participants at modeling sessions reasoning that they could not afford to lose their most vital workers for two months. Consequently, new work processes tended to be engineered by the least vital, least experienced, or least competent workers. As the GSS BPR/BPI sessions were able to accomplish the same model building work in about two weeks, managers became more willing to assign their more vital employees to the task..

### 2.9.5 Lessons yet to be learned about GSS and Business /Process Re-engineering.

In spite of many and varied successes in laboratory and field settings, the use of GroupSystems tools remains relatively small in comparison to the total number of BPR/BPI sessions. It remains to be learned how to successfully capture the attention and attain the commitment of consulting groups and organizations actively involved in BPR/BPI to incorporate GroupSystems technology.

Much remains to be learned in facilitating distributed BPR/BPI sessions. It is not uncommon for organizations to not be able to successfully bring together an optimal set of stakeholders to meet for a sustained period of time. Stakeholders invaluable to BPR/BPI activities are generally similarly invaluable to other organization activities. Being able to actively and successfully involve remote participants remains to be documented.

The extension of GroupSystems technology beyond static modeling to support simulation and animation is expected to be especially useful in helping participants validate complex models as well as assist in evaluating alternative "to-be" scenarios. If successful as anticipated, animation could provide a value added component to BPR/BPI activities.

## 3 Conclusions

Researchers at the University of Arizona have learned a great deal about how to engage in successful GSS collaboration, but still have a great deal to learn. The field is growing rapidly in many different directions. Looking back a dozen years from now today's technology may look horse-and-buggy. GSS will continue to evolve as both technology and processes improve. There will still be problems so intractable that no single person will be able to solve them. Technology will still improve communication, still structure and support thinking processes, and still provide access to information.

As much research as has been done, the surface of GSS research has barely been scratched. For example, we know that on-line communication must be much more explicit than verbal interactions. When teams are geographically separated, the need for explicitness increases an order of magnitude. What can be done to ease communication losses for a geographically separated team? A great deal of research has been done on electronic brainstorming and idea generation, yet idea generation is only a small part of the overall effort a team makes with a GSS. Little research has been done to examine processes for converging quickly on key issues, or for exploring key issues in depth. Far less is known about the organizational changes engendered by GSS. Almost nothing is known about adoption and diffusion of GSS. How and why does power shift within organizations using GSS? How can teams make sense of the vast quantities of information now available to them on-line as they work? The next decade will likely bring some answers, and many more questions.

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**Figure 1.**

**Teamwork Can Be Difficult**

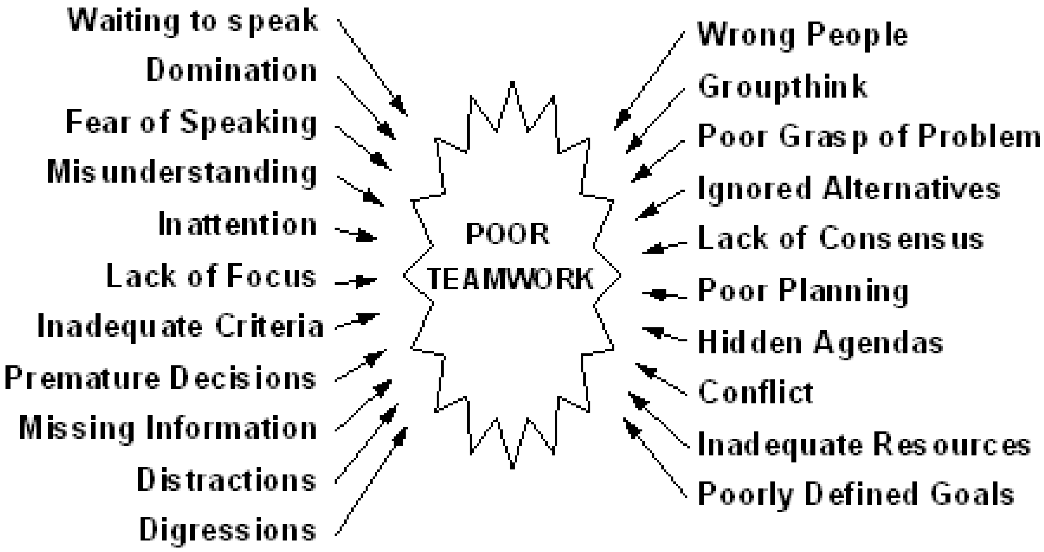



**Figure 2.**

**The Groupware Grid**

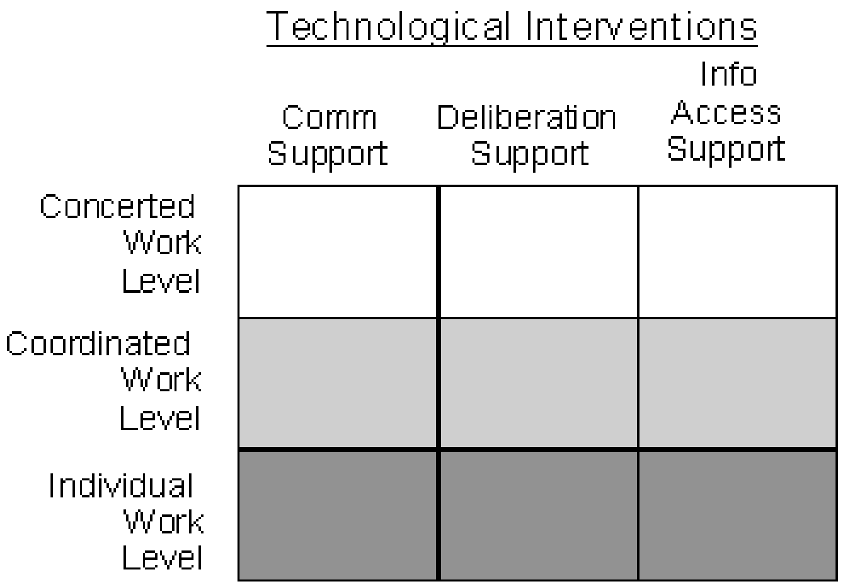



**Figure 3.**

**Three Levels of Group Work**

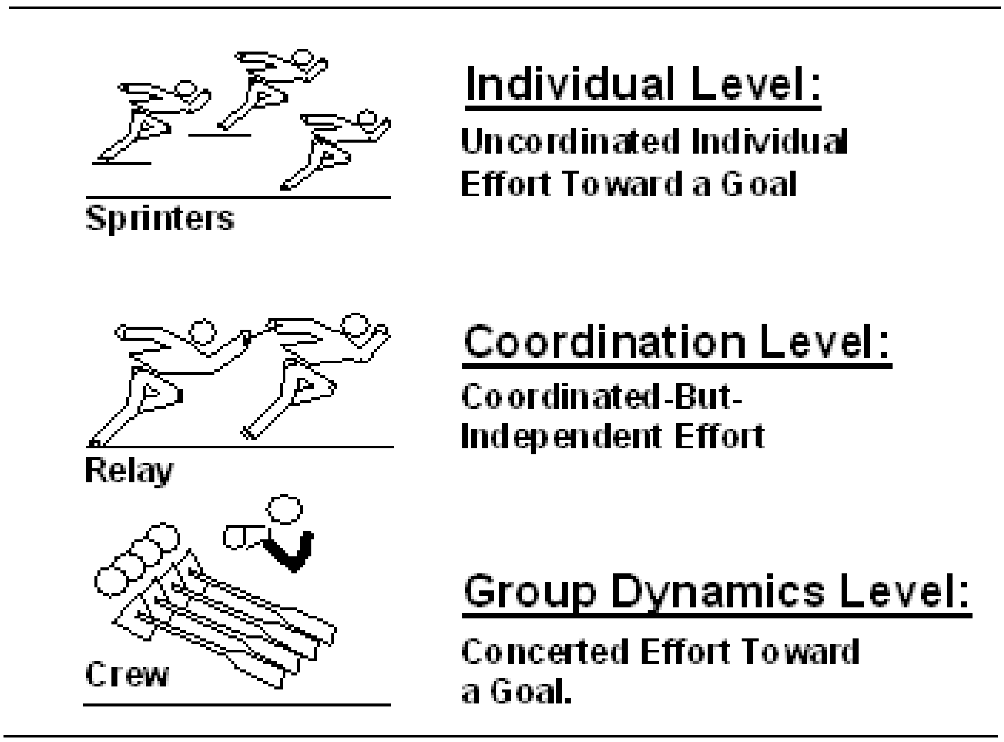
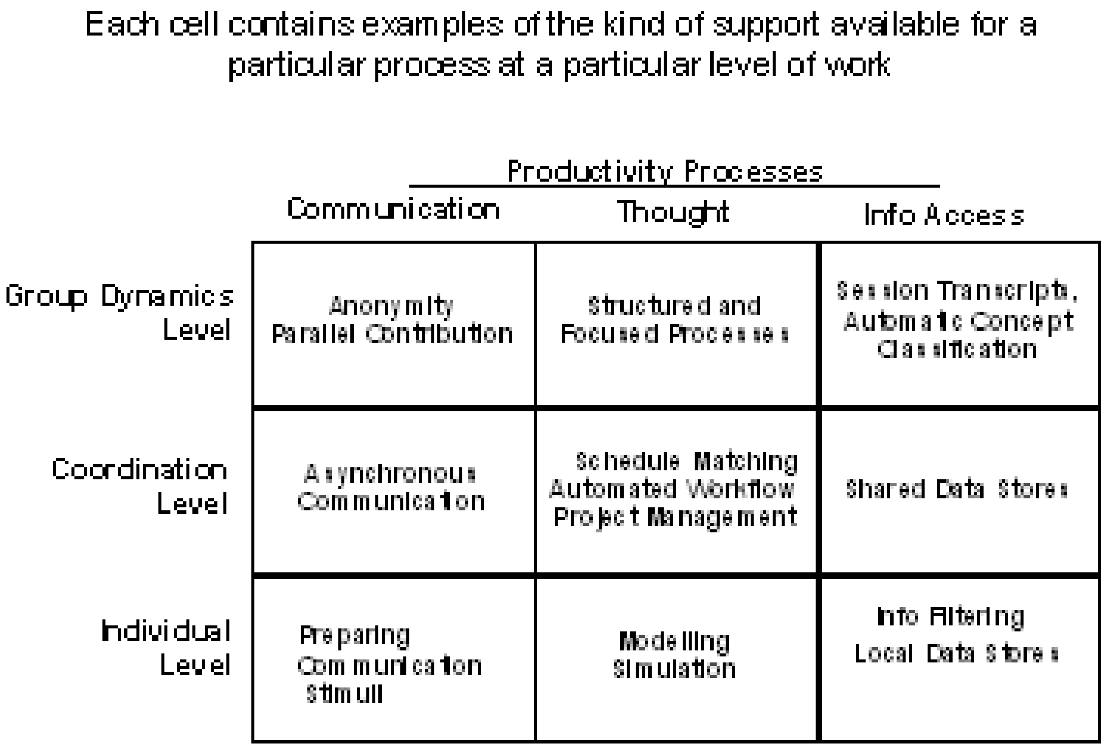



**Figure 4.**

**Classification of Benefits from Group Support Systems**




| **Table 1. Lessons learned about GSS in organizations** |
| --- |
| • GSS technology does not replace leadership. |
| • GSS technology does not imply any particular leadership style. |
| • GSS can make a well planned meeting better; and it can make a poorly planned meeting worse. |
| • Individuals must have incentive to contribute to group effort. |
| • GSS can reduce labor costs by more than 50% and project time by up to 90%. |

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| Table 2. Lessons about participation in GSS groups. |
| --- |
| • GSS can increase the amount of ideas generated during a divergent process. |
| • Meeting participants will be active rather than passive increasing energy and group focus. |
| • Anonymity is a continuous rather than discrete variable. |
| • Anonymity encourages GSS participants to evaluate ideas more objectively. |
| • Anonymous constructive criticism using GSS improves the quality of ideas generated |
| • GSS may increase buy-in to the final result of group effort. |

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| Table 3. Lessons about cross-cultural and multicultural use of GSS |
| --- |
| • GSS can successfully support multilanguage meetings. |
| • Participants from different cultures may demonstrate different levels of satisfaction with GSS implementation. |
| • Behavioral differences across cultures occur primarily in convergent activities. |

-

| Table 4. Lessons about GSS application software |
| --- |
| • Build GSS software as independent special purpose modules |
| • Subtle differences in user interface can make large differences in group dynamics |
| • Keep the user learning curve short; use simple interfaces |
| • Provide easy import and export capabilities both between modules and with external tools |
| • Provide for both task and process support |

| Table 5. Lessons about collaborative writing |
| --- |
| • GSS processes can lead to significant productivity gains |
| • GSS processes can lead to significant increases in buy-in by co-authors to the final document |
| • An appropriate structured process is vital to the success of a GSS collaborative writing project |
| • GSS processes can prevent a group from getting bogged down over wordsmithing |

| Table 6. Lessons about electronic polling |
| --- |
| • GSS polling can be used to clarify communication, focus discussion, reveal patterns of consensus or stimulate thinking. |
| • Anonymous polling can surface issues that remain buried during direct conversation. |
| • GSS polling can demonstrate areas of agreement allowing groups to close off discussion in those areas and focus only on areas of disagreement. |
| • GSS polling can be used to formally register dissenting opinions. |
| • GSS polling can fuse the aggregate judgment or opinions of all group members into a true group position. |
| • GSS polling can facilitate closure of issues that are too painful to face using traditional methods. |
| • Care must be taken to ensure that polling criteria are clearly established and defined. |
| • Polling methods in decision groups need not be democratic. |

| Table 7. Lessons about technology-supported meeting facilities |
|---|
| • The public screen is important for focusing group attention; include two if possible. |
| • Appropriate task lighting is critical to the success of a GSS environment. |
| • Lighting can be used as a facilitation tool to moderate group process. |
| • Provide sufficient desktop space for spreading personal papers. |
| • Provide informal space for social interactions and personal space for reflection. |
| • Map table configuration to expected group activities. |
| • Provide for visual line-of-sight for participants. Non-verbal communication remains a large part of GSS meetings. |
| • Quiet ventilation can be supported by channeling air through the millwork to cool computers and buffer noise. |

| **Table 8. Lessons about facilitation and session leadership** |
|---|
| • Thorough, explicit pre-session planning is critical |
| • The group must always see where they are headed and how each activity advances them towards the goal. |
| • Rehearse all GSS keystrokes so that meeting focus can be on the group rather than the technology. |
| • Small changes in tool set-up make large differences in group dynamics |
| • Expect that ideas generated will change the plan and the agenda. |
| • Mix modes between electronic interaction and verbal/oral interaction. Change locations and alternate between large and small groups every few hours to minimize burnout. |
| • Be cognizant of non-verbal communication behaviors among participants. Even small cues tell a lot |

| Table 9. Lessons about GSS in the classroom. |
|---|
| • GSS enables cooperative learning pedagogies which were not practical to implement before. |
| • Using real problems which students find salient energizes participation and learning. |
| • The most at-risk learners can become the classroom leaders. |
| • Teacher user-interfaces must be made simple so they may attend to their students instead of the computer. |

| Table 10. Lessons about GSS for BPR/BPI |
|---|
| • GSS supports larger more heterogeneous BPR/BPI teams. |
| • Special purpose modeling and graphical GSS software is desirable. |
| • GSS can reduce the time required to complete a modeling process. |
| • GSS can aid in data collection from subject matter experts but they experts still require facilitation assistance in organizing data relationships. |