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Design and evaluation of a list gathering tool in a web-based collaborative environment

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ABSTRACT

DESIGN AND EVALUATION OF A LIST GATHERING TOOL IN A WEB-BASED COLLABORATIVE ENVIRONMENT

by
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This research focuses on how to build a "list" structure to combine individual items of information into some sort of structure that converts the individual items of information into a structure of knowledge relative to the problem. Software was designed to provide relationships among and comparisons of the contributions in a "list" structure, so that individual members of a group process will be able to understand the contributions of information made by the group as a whole.

A List Gathering Tool was designed and implemented, which is one component in a Web-based Social Decision Support System (SDSS) Toolkit. Then, a two-by-two factorial design (list tool support vs. no list tool support, and voting tool support vs. no voting tool support, respectively) controlled experiment and several field studies were carried out to assess the effects of this List Gathering Tool in a group problem solving process.

Overall, the evaluation results are encouraging. The utilization of the List Gathering Tool or the SDSS Toolkit does tend to improve the ability to discover valid alternatives. An additional set of field trials illustrated how the SDSS Toolkit can be utilized in a collaborative learning environment to improve teaching and students' learning experience. This system will also work for very practical applications in large group settings.

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by
Yuanqiong Wang

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Zheng Li, Yuanqiong Wang, Murray Turoff, and Starr Roxanne Hiltz, "Using a SDSS Toolkit to Evaluate Knowledge Building in a Virtual Community", ISOneWorld Conference and Convention, Las Vegas, Nevada, USA, April 23-25, 2003.

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This dissertation is dedicated to my beloved family

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CHAPTER 1

INTRODUCTION

It is estimated that managers and professionals in different organizations spend between 25% and 80% of their time in meetings, with approximately 50% of that is wasted as a result of information loss, information distortion and sub-optimal decision making (Dufner, Hiltz, Johnson, and Czech, 1995; Hymowits 1988; Smith, 1989). With recent advances in computers, telecommunication and management science techniques, serious efforts have been made to use technologies to enhance group performance.

Many Group Decision Support Systems (GDSS) have implemented software tools to collect ideas, votes or rankings from group members, and present the results to the group. Theorists and researchers have explored how interventions of computer support for group communication and group decision-making produce low or high quality of group decision-making (Nunamaker, Vogel, and Konsynski, 1989, Fjermestad and Hiltz, 1999, 2000). However, in most cases, tools used in those studies are just black boxes to other researchers. Researchers seldom look into the differences in using different structures provided by different software packages. For instance, when talking about "electronic brainstorming system (i.e., EBS)", people always do not care which components are in it, and what kind of effect each component may contribute to the whole group process. This might be one of the reasons why some of the results cannot be replicated from previous studies. In order to get a full understanding of the effects of those tools, more research on different components/features in the tools deserves full attention. Also, most of the computer-supported efforts studied have been of synchronous face-to-face groups. More work is needed in getting the understanding of the effects of those tools that can support asynchronous group decision-making.

Voting tools are implemented most often in various Group Decision Support Systems. A structure that sits underneath the voting tools to help capture and allow collective organization of the lists of options that must be voted on is essential for researchers to get a full understanding of the group process. Rather than a free for all system, one has to have a system that allows the people's input to adjust their contributions and indicate relationships among them in a highly easy to do manner. The more complex the problem is, the more people with knowledge and/or expertise are needed to deal with it. In Nominal Group Technique (Van de Ven and Delbecq, 1974), the Delphi Method (Linstone and Turoff, 1975; Turoff and Hiltz, 1995), and the Brainstorming (Osborn, 1957), there is a history of methods to develop a structure that converts individual items to a structure of knowledge. Such knowledge structures allow individual members of a group process to understand the contributions of information made by a group as a whole by providing relationships among and relative comparisons of the contributions. There are very common structures (e.g., payoff matrices which are a list of actions interacting with a list of outcomes, etc.) used for the analysis of complex problems. However, they are all made up of one or more fundamental lists of individual items. Therefore, the *list* is critical to all else and a foundation for everything else in decision-making.

In order to find a good structure for such lists, researchers want to get more the classical Delphi ability to set up a structure to deal with a number of related lists simultaneously. The author has built a "List Gathering" tool, which is one of the key components in the Social Decision Support System (SDSS) toolkit, to support such a structure. It is distinguished from other idea-gathering tools or brainstorming tools in that rather than being limited to one single list, it can deal with multiple lists that have relationships. A Social Decision Support System is a type of inquiry system that supports the investigation of complex topics by large groups which hold many diverse and opposing views (Turoff, Hiltz, Cho, Li, and Wang, 2002).

Currently, the web browser is becoming the standard client for many client-server applications. Researchers are hoping to see the web can be viewed as a place where individuals can work together to generate ideas, discuss problems, and make decisions, despite whether they are in the same room, or halfway around the world. A lot of systems that claim that they can help group in collaboration are available on the Internet. However, most of them are lack of flexibility for group members to adjust their way of using it. With the development of the World Wide Web, how to make tools available on the web and be used effectively deserves more research.

This research tries to build a List Gathering Tool to provide a structure for people to solve complex problem collaboratively in a Web-based collaborative environment. This List Gathering Tool combined with a voting tool, designed and implemented by Zheng Li, is called a Social Decision Support System (SDSS) toolkit. A controlled experiment and several field studies have been conducted to evaluate the effects of the List Gathering Tool interacted with group process, and to explore the possible application areas of such a toolkit.

Next chapter reviews some theoretical frameworks that guided this research. Then, a brief review of the literature on the list gathering process is followed. After the review of the current idea collecting tools' implementation, principles of the List Gathering Tool design are presented in Chapter 5. Chapter 6 describes the List Gathering Tool evaluation process, including protocol analysis and the controlled experiment. Chapter 7 discusses data analysis and the results from the experiment; Chapter 8 presents the procedure and main results of several additional field trials; final discussion, future research directions and contributions of this research are discussed in Chapter 9.

CHAPTER 2

THEORETICAL FRAMEWORKS

According to Fjermestad and Hiltz (1999, 2000), there have been large number of different group support technologies made available and empirical studies within these decades. A solid theoretical foundation is needed to understand the various group techniques and research results generated from those studies. This chapter presents a brief review of those theoretical frameworks.

2.1 Group Decision Support Systems (GDSS)

During the last three decades, theorists and researchers have done a lot of research on how interventions of computer support for group communication and group decision-making produce low or high quality of group decision-making. There is an explosion in the number of GDSS available. For example, AMIGO Advanced, Answer Garden, CHAOS, COM, Coordinator, Cosmos, COSY, EIES 1, EIES 2, Group Issue Analyzer, GroupSystems, Information Lens, Lotus Notes, Object Lens, PortaCOM, SAMM, SuperCOM, VisionQuest, Vaxnotes (Bignoli, 1991; Bostrom, Watson, and Kinney, 1992; Dollimore, 1988; Malone, 1987; PALME, 1990; PALME-THOLERUS, 1991; Pankoke, 1989; Winograd, 1986; etc). These systems are always called group systems, group decision support systems, groupware, decision support systems, computer-supported cooperative work systems, electronic meetings, etc. What is a "Group Decision Support System"?

Huber (1984) defined the group decision support system (GDSS) as a technology whose basic purpose is to improve the effectiveness of decision groups by assisting the interaction and use of information among group members and also between the group and the computer. It refers to a computer-based process by which to conduct group meetings. Generally there will be a computer terminal, at times one for each group member, that will run a program, which allows inputs from members. The program then responds to inputs by the members and at times can be quite directive while at other times can just facilitate a computer-based discussion. It can help a group of decision makers to solve unstructured or semi-structured problems (DeSanctis and Gallupe, 1987). By removing communication barriers, offering structures for the group interaction, and providing analytical tools such as decision aids for data-oriented, preference, or resource allocation tasks, it can help groups improve decision making process (DeSanctis and Gallupe, 1987; Hiltz, Dufner, Holmes, and Poole, 1991). Existing GDSS support many group activities, including: idea generation/brainstorming, weighting of ideas, rating of ideas, ranking of ideas, voting on ideas, stakeholder analysis, resource allocation, comparison of paired ideas, connecting/linking ideas, grouping ideas into categories, logging the meetings, and so on (Dennis, George, Jessup, Nunamaker, and Vogel, 1988; Dickson, Poole, and DeSanctis, 1989).

Some well known systems include the University of Minnesota's SAMM system, the Capture Lab in Michigan, the University of Arizona spin-off GroupSystems (marketed by Ventana), as well as the version called TeamFocus by IBM, and VisionQuest marketed by Collaborative Technologies Corporation. Each system consists of a number of different tools that are intended to assist in aspects of a group decision-making process. These tools have evolved over the years as a result of experiences of use. There is support for brainstorming activity, for ranking alternative choices and voting, for preserving anonymity, etc. The focus has been on the support of co-located synchronous teams. With the current global economy, more and more organizations are utilizing online software to facilitate collaboration. In this case, the technology used in the GDSS can be adapted for use in remote situations or for asynchronous use.

Most previous GDSS are combined with face-to-face interaction in a decision room setting. It can also be embedded within a computer-mediated communication system (CMCS), which has been also been called a "Group Communication Support System (GCSS)" by Pinsonneault and his colleagues (1990). This kind of system provides a single interface for users that could be used in the decision-room environment, by groups distributed in space but not in time ("synchronous" computer-mediated communication). Another type of system can support "asynchronous" groups that are not only distributed in space, but whose members participate at times of their own choosing, spread over days or weeks. However, this is not simple.

In the field of GDSS research, there are conflicting findings. Some researchers found that computer supported groups produced higher quality and more creative solutions, generated more alternatives, and reduced domination by a single leader, compared with non-supported groups. Others found that GDSS did not increase group consensus, etc.

How to interpret those conflicting findings in the literature? There are some conceptual frameworks proposed from different perspectives by different researchers. Some of the frameworks are discussed in the next several sections.

2.2 Contingency Theory

DeSanctis and Gallupe (1987) built the foundation for the study of Group Decision Support Systems (GDSS). They established a contingency perspective for studying GDSS. They proposed that different GDSS tools and social processes would be optimal for different types of tasks or problems. All theories depend on three dimensions: member proximity, task type and group size (Figure 2.1).

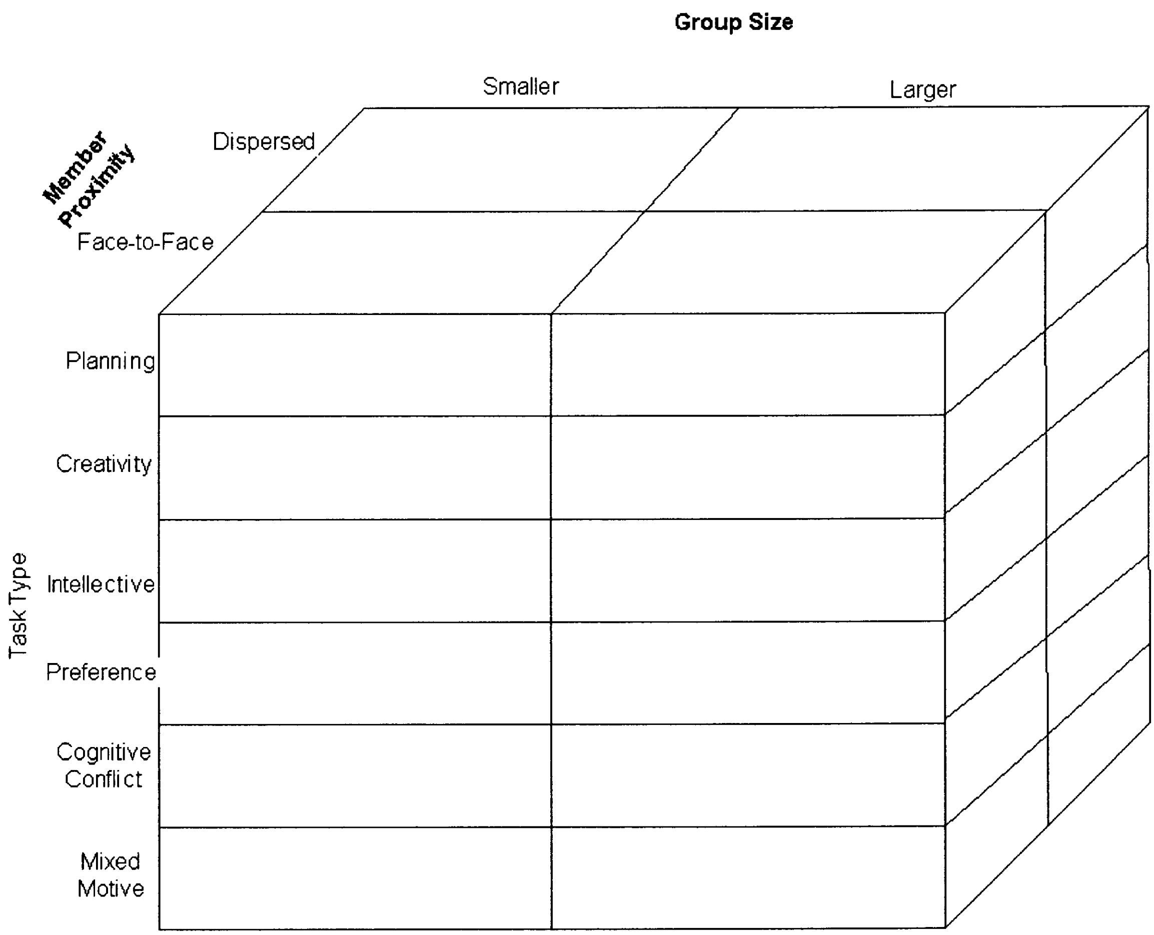

Figure 2.1 Foundation for the study of Decision Support Systems (DSS). (Source: DeSanctis, G. and Gallupe, R. B., 1987.)

Member proximity refers to whether the members of the group are in a face-to-face condition, or in a dispersed setting. *Task type* includes planning, creativity, intellective, preference, cognitive conflict, mixed motive (McGrath, 1984). *Group size* could be a smaller group, which has fewer than five people, or it can be a larger group, which may have more than 100 people. There is no one single tool, which can be suitable to all circumstances. In this theory, they assume each group member will participate at the same time, which means that their theory is limited in "synchronous" communication mode. However, in a group setting, group members should be able to participate in decision-making activities in any place, at any time as they want – especially current technology of the Internet make it possible to get contact and involve in group activity at place and time which is convenient to group members. This introduces one dimension to be extended.

Hiltz and her colleagues (1991) realized the need for "asynchronous" communication. Therefore, they extended DeSanctis and Gallupe's contingency perspectives to include the communication mode as both "synchronous" and "asynchronous", which means for member proximity, group members can be in a face-to-face condition, physically dispersed, or in an asynchronous condition. This model is shown in Figure 2.2. According to this theory, some types of problem, for instance, involving conflict or extensive ambiguity, may be good for face-to-face groups, but they may be very difficult for dispersed groups. Different tools may have good effects for small groups, but not for larger groups. Asynchronous use of technologies may lead to different communication behaviors and to some unique coordination problems (Dufner, 1989; Dufner, et al., 1994; Hiltz, et al., 1989; Hiltz, et al., 1991; etc).

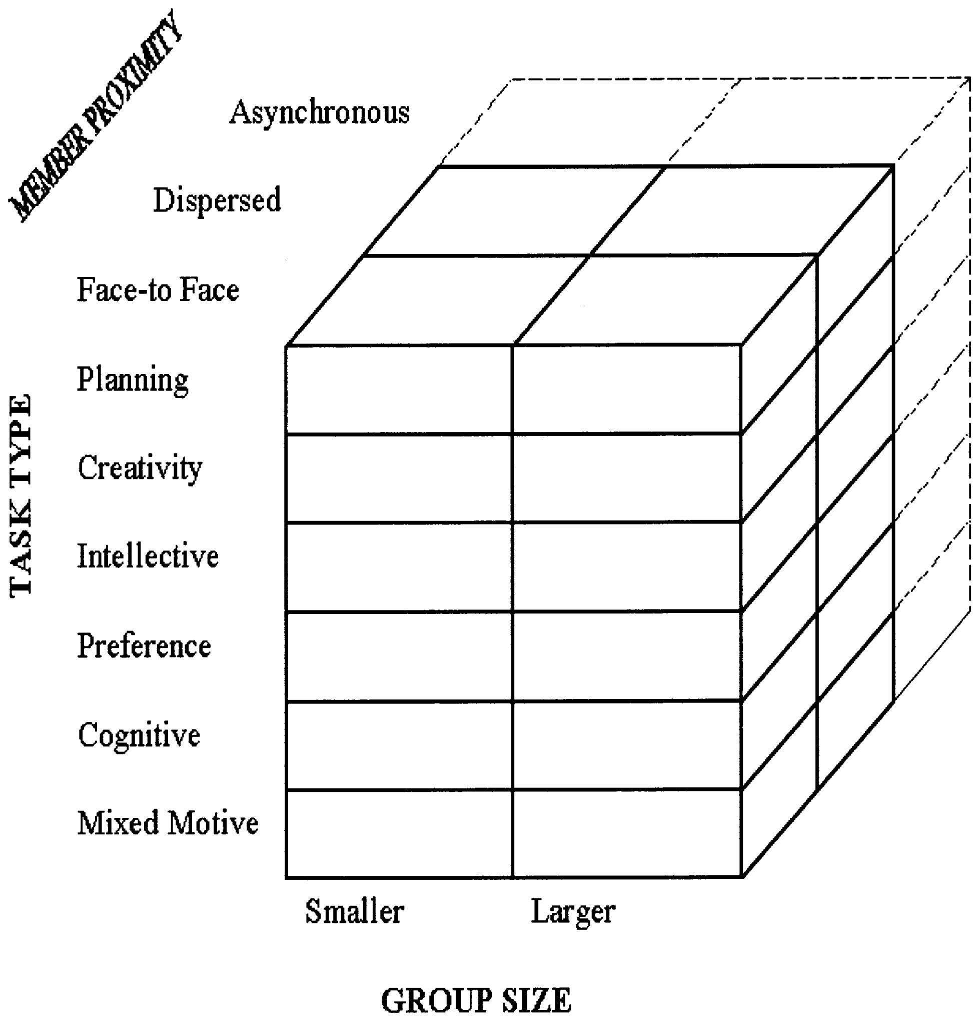

Figure 2.2 Contingency perspectives for GDSS research.
(Source: Hiltz et al., 1991.)

2.3 Adaptive Structuration Theory (AST)

The theory of adaptive structuration attempts to explain how technology affects group processes and resultant outcomes. The effects of an information system may not be the same as what the designers or researchers have expected. The user behavior often differs from the impacts that the designers or implementers "intended" for the technology (Siegel et al., 1986; Watson et al., 1988). Groups will adapt systems to their particular needs and situation, or resist them or fail to use them at all. For the "same" technology, there are different patterns of appropriation, and therefore, the effects on decision-making and other outcomes will not be the same. Group members have different cognitive backgrounds; therefore, there will be limitations, biases, and other deficiencies in a group process caused by social pressure or cultural differences. Decision procedures that provide structures for the group will be incorporated in GDSS. The Group, as a social system, has a pattern because the members use rules and resources to create and support the status hierarchy. The structural features constrain and direct the possible actions a group may take, as well as provide the group with different options. Appropriation of a GDSS involves a particular adaptation of the rules and resources that the GDSS makes available (Poole et al, 1990). Implementers should not expect groups to use a computer-based support system in their predefined ways. Users may alter the system when they use it. The point is to understand *how users alter systems*.

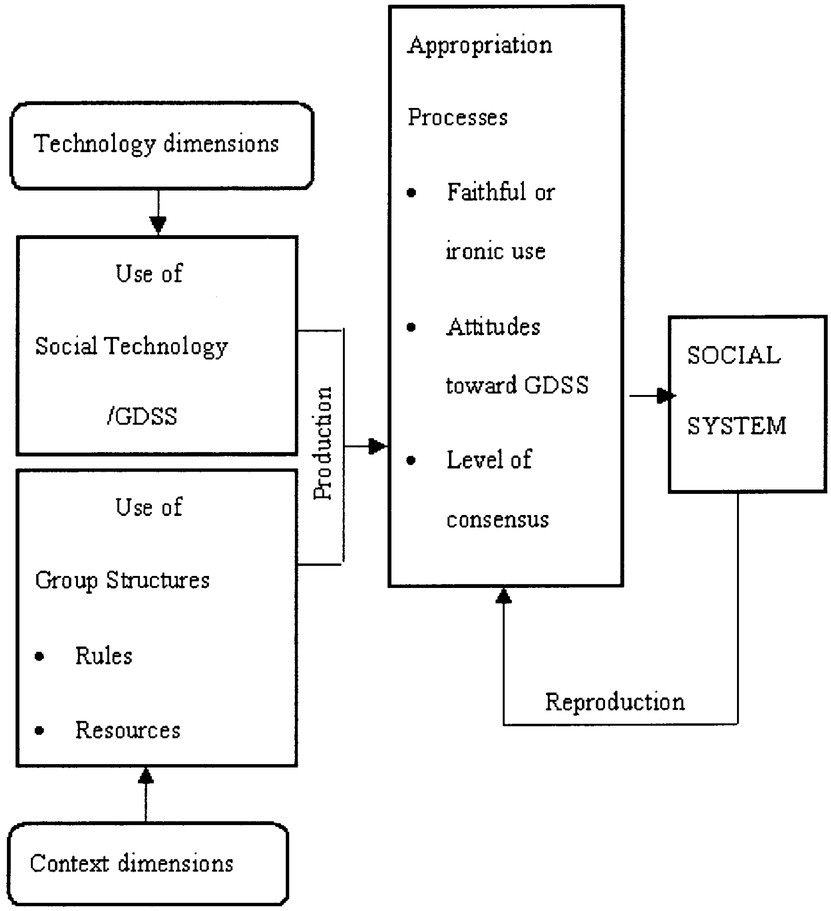

Figure 2.3 Overview of adaptive structuration process.
(Source: Hiltz et al., 1991.)

There are at least four dimensions of modes of adaptation: *control, attitudes, faithful versus ironic appropriation, and level of consensus* (Hiltz et al. 1991). *Control* means that group members can use the GDSS in ways that were designed by the designers, or they can alter it as they need. *Attitudes* refer to the level of comfort with, and level of respect for the technology. *Faithful versus ironic appropriation* means that users can follow the instruction "faithfully", or revise and reject. *Level of consensus* refers to the extent to which the members of group have consistent adaptations on the preceding three dimensions.

2.4 Task Circumplex

Regarding the issue of tasks, McGrath (1984) proposed the most commonly adopted scheme in GSS research -- "Task Circumplex". He developed a typology that provides a task classification, which distinguishes four categories of major activities or objectives, each with two subcategories of task types:

A Generate

A.1 Planning tasks: Generating action-oriented plans.

A.2 Creativity tasks: Generating ideas (for instance, brainstorming)

B Choose

B.1 Intellective tasks: solving problems with correct answers

B.2 Preference/decision-making tasks: deciding issues with no right answer, the goal is to reach consensus.

C Negotiate

C.1 Cognitive conflict tasks: resolving conflicts of viewpoints, preference structures, or interpretation of information.

C.2 Mixed-motive: resolving conflicts of motive/interest

D Execute

D.1 Contests/battles/competitive tasks: resolving conflicts of power

D.2 Performances/psycho-motor tasks: Executing performance tasks

Execute types of tasks are usually not included within the area of group decision support because they are "post-decision".

McGrath's Time Interaction and Performance (TIP) theory (McGrath 1991) acknowledged the fact that the tasks undertaken by real life groups do not always comprise single, simple, and mutually exclusive performance process. It posits that the activities of a naturally occurring group can consist of more than one task (or performance process). The "performance processes" are treated as non-sequential potential modes of activity. It relates only to a group's production functions.

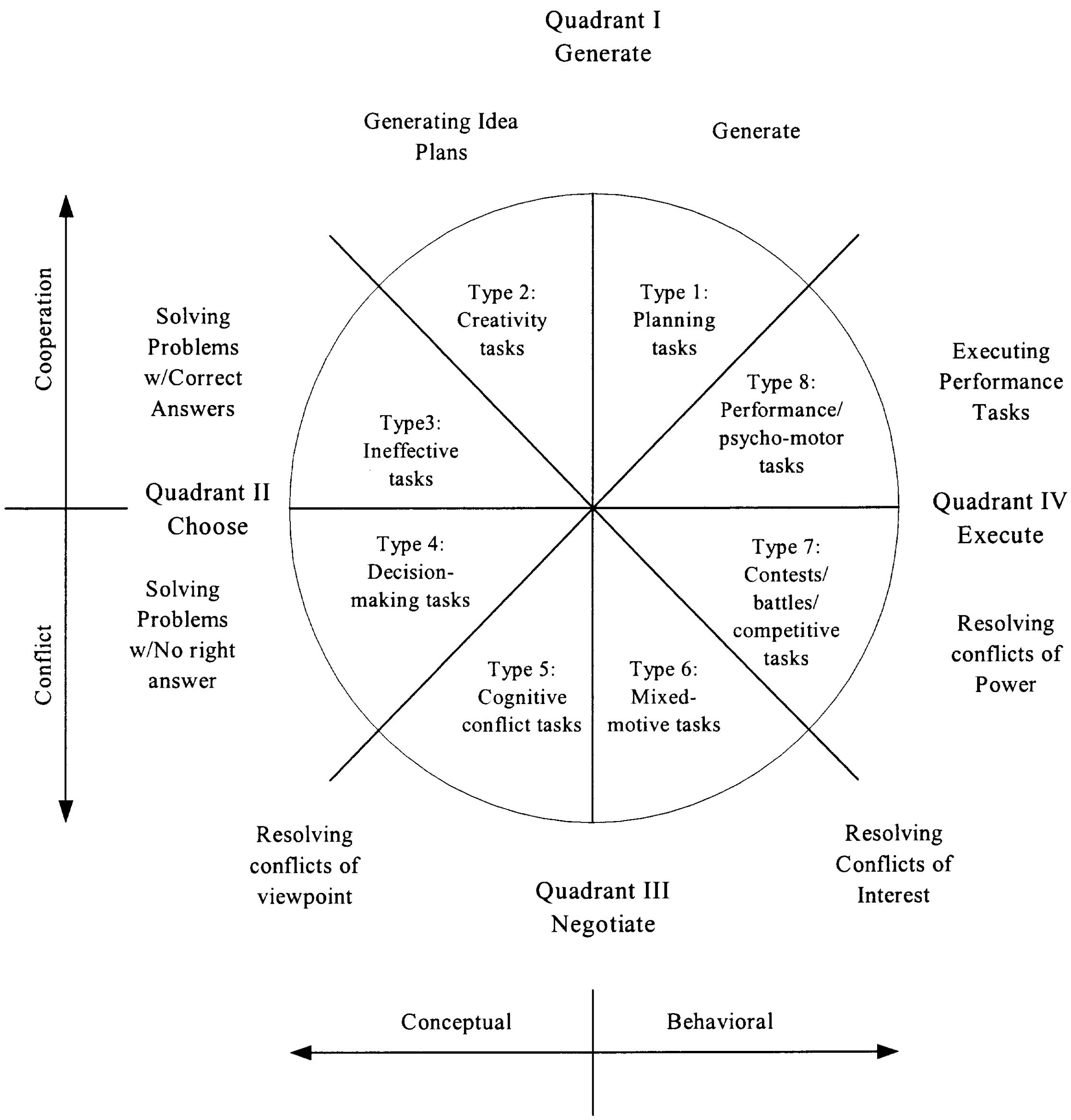

Figure 2.4 McGrath's circumplex model.
(Source: McGrath 1984.)

2.5 Task Technology Interaction Theory

Turoff and Rana (1997) pointed out that McGrath's task circumplex theory is limited in its usefulness for determining technological support features for real life tasks, those tasks for which GSS technologies are observed to be most beneficial. The limitation of McGrath's Circumplex is its insistence upon mutually exclusive categorization of tasks based upon pure mode performance processes, and lack of explicit recognition of task complexity, whose importance is becoming apparent in the research on GDSS.

The "Task and Technology Interaction (TTI)" theory (Rana, 1995; Rana, et al., 1996; Rana, Turoff & Hiltz, 1997; Rana & Aljallad, 1997) is an integration of the implications of TIP theory (McGrath 1991) and the AST (Poole & DeSanctis, 1990). Task and Technology Interaction theory defines GSS as a combination of electronic or non-electronic features taken from three broad classes of generic support types: *the individual support; group process support; and meta-process support.* The task classification scheme in TTI is based on the notion of functional requirements of tasks. It defines the task distinctions along three ordinal dimensions -- *complexity, validation, and coordination.*

- Level of complexity

The level of complexity includes:

Structured: assume that a well understood standardized framework exists to address this type of problem;

Semi-structured: assume that a generally acceptable structure exists that can be applied to the problem, but inter-relationships among the components of the problem are not fixed;

Unstructured: no accepted framework exists to address the problem; and

Wicked: has no accepted framework, and the problem is too complex to lend itself to the development of a structure by the group or its members.

The different levels of complexity represent the critical task contingencies along the complexity dimension. They posit that the analysis on the functional requirements of the task along the complexity dimension will be helpful in determining the appropriate technological features grouped under the precept of support for the individual. This indicates that functional requirements for a system depend on the complexity of the task. Therefore, consideration on the complexity of the task in the design process will assist designers decide the best set of features to provide.

- Validation approach

Validation approach refers to the implicit or explicit approach that a group adopts, or the task instructions expected the group to adopt for validating (or assuring) the true content of the process outcome. The categories of this dimension are borrowed from the work by Churchman (1971), Merleau-Ponty and Heidegger (1967). It includes *deductive, inductive, relative, negotiated, and conflictual.* Turoff and his colleagues (1995) posit that functional requirements analysis of the task along the validation dimension will be instrumental in determining the appropriate technological features grouped under the precept of group process support.

- Coordination approach

The coordination approach refers to the implicit or explicit approach that a group adopts, or is expected to adopt based on the task instructions, in order to manage the flow of work. This classification was derived by Thompson (1967). The major coordination modes are:

- *Parallel*: each individual approaches the problem independently of the other members of the group, no group view imposed;
- *Pooled*: same as parallel except that a structure or standard is utilized to formulate a group result (for instance, voting), which means that a group view is generated in this mode;
- *Sequential*: a group imposes phases on the problem-solving process that must be undertaken in a sequential manner by all the members of the group (e.g., step-by-step agenda). In this mode, group views are imposed;
- *Reactive/reciprocal*: changes made in one part of the problem can force reconsideration of other parts of the problem. In this mode, group views are also imposed.

The impact of the above coordination modes used by groups are shown in Table 2.1.

Table 2.1 Impact of Coordination Modes

Coordination Mode	Group View	Individual Inputs	Group Results
Parallel	No group view imposed	Independent, asynchronous	Summation
Pooled	Group view imposed	Synchronous	Cumulative
Sequential	Group view imposed	Asynchronous	Synchronized
Reciprocal	Group view imposed	Asynchronous	Synchronized

In Task and Technology Interaction theory (Rana, 1995; Rana, et al., 1996; Rana & Aljallad, 1997; Rana, Turoff & Hiltz, 1997), researchers posit that functional requirements analysis of the task along the coordination dimension will be instrumental in determining the appropriate technological features grouped under the pre-meta process support.

The positioning of a task along each of the three dimensions is based on the identification of a range of attributes. Turoff et al. (1995) call these distinguishing attributes "*critical task contingencies*". They argue that the identification of such contingencies helps in the determination of the activities that could fulfill a task's general functions and hence facilitates the determination of technological features that could support/enhance the performance of those activities.

2.6 Hypertext Morphology

Frameworks discussed in the previous sections emphasized the need for flexible design according to different levels of complexity/types of the task, different coordination approaches, different group sizes, and member proximity. In addition to these general considerations, the ability for group members to find relationships between different ideas during a decision-making process should be also provided. For this purpose, a Group Decision Support System architecture provides hypertext templates composed of semantic nodes and links is necessary. A problem-solving process structure, which uses a semantic hypertext template, can be helpful for groups. A universal hypertext classification schema used for appropriating information in hypertext nodes and for typing semantic links, based on hypertext morphology can assist in this regard.

Turoff et al. (1991) classified hypertext nodes as follows:

Table 2.2 Hypertext Nodes Classification

Cognition	Description of node	Convergent production	Divergent production
Node type		Links	Links
Detail	Fact, definition, reference	Specification	Elaboration
Collection	Group, heading, aggregation, set	Membership	Opposition
Proposition	Assumption, belief, axiom, law	Association	Speculation
Summary	Generalization, overview, template	Path	Branch
Issue	Question, problem, concern, vision	Alternative	Lateral
Observation	Conclusion, decision, action, policy	Inference	Extrapolation

This morphology aims at the development of a common implementation model. It is to establish a classification system for all nodes and links. With this hypertext morphology, information is appropriated, stored and hypertext links typed, based on the nature of the node and the link usage. This approach can give group members more hints on the relationship and make it easy to find related information. By using this morphology, it is possible to create powerful semantic links. Information can be stored in a hypertext system according to a specific category it belongs to. It can also help to create specific types of hypertext links, which can be used to categorize the nature of information flow between hypertext nodes. By using hypertext-based communication structures, human roles, and creation of collaborative expert systems, collective intelligence can be promoted.

2.7 Communication Process and Problem Solving

2.7.1 Process Gains and Process Losses

A group process always involves process gains and process losses. University of Arizona developed the "GroupSystems" as their research environment. They have emphasized on process gains and process losses in their research framework. Pinsonneault and his colleagues (1999) argue that the performance of brainstorming technology can be calculated as the net sum of the process gains and the process losses. There are different types of communication structure. Therefore, according to the contingency theory, the process gains and the process losses might not be the same for different types of the communication structure. Some process gains might be increased in one communication structure, while it can be reduced in another communication structure because of the characteristics of different communication structure. Meanwhile, different leadership and facilitation methods, group memory, anonymity, coordination modes, task structures, and process tools will influence the group process gains and process losses as well.

In this section, the author presents a list of process gains and process losses in the literature and discusses potential solutions for them first, then discusses the different process gains and losses in different communication structures.

2.7.1.1 Process Gains. The process gains and possible ways to increase them (Turoff, 1999) that have been found in the literature are as follows:

- **Separation of task processes:** Decomposition of tasks into subtasks has been found to increase productivity. By giving task support, groups are able to decompose tasks into subtasks no matter which communication mode they are using. However, some information may be lost after decomposition, therefore, it might lead groups to get sub optimal results.

- **Cognitive stimulation/synergy:** Receiving verbal or textual cues from peers may elicit new ideas. Therefore, by discussing among group members, one can get a deeper understanding on issues.
- **Observational learning:** Members can imitate and learn from the best performers and thus increase productivity. This can be improved by allowing users to identify themselves when they post ideas or to see how other group members contribute in terms of quantity of ideas, quality of ideas, etc. However, this might not be true when all group members perceive themselves as experts in the problem they are dealing with. With identification, some members might dominate the group discussion and lead the group to sub optimal solutions.
- **Social recognition:** Individuals want their contributions to be recognized by others. By allowing users see the numbers of contributions per individual, the member who contributes most will be recognized. However, some studies do show that members who contribute most are not necessarily the best members.
- **Task orientation:** Being focused on the task improves productivity.
- **Motivational arousal**: Working as one part of a group may stimulate and encourage individuals to perform better. By giving each group a separate place to work on, this gain can be increased. Also, group members' motivation might be increased by allowing individuals to work on separate tasks according to individual's cognitive style. Thus, a GDSS should allow group members to work on any aspect of the problem at any time.

- **More objective evaluation**: Groups are better at catching errors than is the individual with proposed ideas. However, this might cause problem of not working on proposing ideas but trying to be picky.
- **More information**: A group as a whole has more information than anyone group member. However, if a system does not have a good structure to organize and present the information, "information overload" will not be prevented.

The above discussion illustrated the possible process gains that an appropriate system may bring to groups. It is essential for designers to identify appropriate structures/mechanisms that a GDSS may provide to increase process gains. However, increase one process gain too much may actually bring another process loss. For example, while a GDSS may present more information to groups, it may cause information overflow if it does not present a good structure to help group members organize information. Therefore, such trade offs cannot be avoided and should be taken seriously when designing a GDSS.

2.7.1.2 Process Losses. The process losses and ways to avoid them (Turoff, 1999) that have been found in the literature are as follows:

- **Production blocking**: Unable to express ideas as they occur due to social norms, such as waiting to speak is known to reduce productivity. This includes *attenuation blocking* which occurs when members who are prevented from contributing comments when they occur, forget or suppress them later in the meeting, as they seem less original, relevant or important; and *concentration block* which occurs when members concentrate on remembering comments (rather than thinking of new one) unless they can contribute them, fewer comments are made. By accessing system online any group member can input his/her ideas at the same time; this loss can be eliminated.

- **Effort redundancy**: When many individuals are working on the same or similar ideas, unaware of each other, a lot of efforts are wasted without any additional gain. By allowing group members see what other group members input, redundancy can be reduced. In a GDSS, this might be able to be avoided by implementing information retrieval technique to automatically sift out those duplications.
- **Cognitive interference/Concentration blocking**: People get overly engaged in other contributor's suggestions instead of generating their own ideas. This always happens when time is limited. For asynchronous communication, time is not limited to a timeframe. Therefore, using asynchronous communication can reduce this kind of process loss.
- **Cognitive inertia:** Individual become too focused or trapped in a single train of thoughts. This might be avoided or reduced by forcing individuals to generate his/her own ideas before discussion, in the middle of the discussion, or after voting. In an asynchronous communication, people will have abundant time to think before discussion, this might help to reduce this kind of loss. However, a deadline might have to be set although not so tight for groups to start their work. Otherwise, groups might be just waiting for others' input.
- **Evaluation apprehension**: People hesitate to express ideas in fear of what others may think. Giving group members opportunity to post ideas anonymously or using nickname can eliminate this loss.

- **Negative productivity matching**: This might happen when group members adjust individual productivity to a (lower) baseline level.
- **Pressure for cognitive conformity/uniformity**: When group members can be identified, individuals may feel pressured to remain within certain group norms or subscribe to a given set of values. Using anonymous input or nicknames can reduce this kind of process loss.
- **Conformance pressure**: People might reluctant to criticize the comments of others due to politeness or fear of reprisals.
- **Personalization of issues**: Individuals associate the discussed ideas to personal matters. Usage of anonymous input can reduce this loss.
- **Social Influence**: Dominant group members can cause problems by exercising undue influence. By allowing anonymous input, all ideas are treated equally. Individuals will not be able to dominate.
- **Social loafing**: Rely on others to accomplish goals, due to cognitive loafing. This might happen when members feel that their contributions are not being recognized, when they perceive that their input is not needed, or because there is not enough airtime. It is also called "free-riding". Recognizing each group members' contribution or using asynchronous communication support can reduce this.
- **Attentional production blocking**: While formulating and entering ideas, member are unable to pay attention to others' contributions. This is due to the limited time frame in synchronous communication. This can be reduced by using asynchronous technology.

- **Striving for originality**: Attempt not to replicate an idea already entered. Members are too focused on other members' ideas, which block them from coming up with original ideas of their own. Asynchronous communication can reduce this.
- **Cognitive complexity**: In a synchronous communication mode, group members need to simultaneously read, understand, and interpret other's ideas. Therefore, the complexity is higher. Asynchronous communication gives group members more time to mediate on the comments made by other members. Therefore, this kind of loss can be reduced.
- **Cognitive dispersion**: Group members are exposed to several ideas along different lines of thought. This might be a process gain -- when dealing with a very complex problem by people with various expertise, they will provide ideas from different points of view, which might help them find an optimum solution. By using asynchronous communication and a good structure of presenting individual items, this process loss can be converted to process gain.
- **Information overload**: This is a serious problem in computer-mediated communication. This happens when people are having too much information to deal within the time and with the human memory limitations available. Some solutions for reducing this have been proposed by researchers (Chen et al., 1994; Chin et al., 1992; Dennis, 1996; Eden et al., 1992; Gallupe et al., 1991; Nagasundaram et al., 1993; Nunamaker et al., 1991). For example, use queuing and filtering information, round robin idea generation to reduce total number of ideas generated, use more intuitive user interface, sort ideas into batches, automatically indexes and clusters ideas into

common categories, cognitive mapping, etc. There is a tendency to find a structure to solve the problem.

- **Socializing**: People spend time on non-task discussion which reduces task performance although some socializing is usually necessary for effective functioning.
- **Failure to remember**: Members lack focus on communication, missing or forgetting contributions of others. A system which provides group memory can eliminate this.
- **Coordination problems**: Difficulty integrating members' contributions because it does not have an appropriate strategy, which can lead to dysfunctional cycling or incomplete discussions resulting in premature decisions.
- **Incomplete use of information**: Incomplete access to and use of information necessary for the successful task completion. This loss can also be regarded as a consequence of synchronous communication, which has only limited time to think about the task. A system, which provides group members the flexibility to choose when to contribute, will largely reduce this kind of loss.
- **Incomplete task analysis**: Incomplete analysis and understanding of task result in superficial discussion. This can be reduced by using asynchronous communication. A system which allows group members to choose when and in which aspect to contribute will eliminate this loss.

2.7.1.3 Potential EMS Effects. Four theoretical mechanisms have been proposed to change the balance of process gains and losses. They are: *Process Support, Task Support, Process Structure,* and *Task Structure.*

Process support refers to the communication structure that allows group members to communicate with each other. Parallel communication, anonymity, and group memory can be provided by the system to increase group process gains.

Process structure refers to techniques or rules to guide a group process in terms of pattern, timing or content of the communication. A process structure can be global or local. For instance, develop an agenda as a global structure, while use some automatic techniques in a specific activity is a local process structure.

Task support refers to the information and the structure for task-related activities.

Task structure refers to techniques, rules, and models for helping analyze task-related information.

Nunamaker et al. (1992) presented the interaction between the type of support and process gains and losses as showed in Figure 2.5.

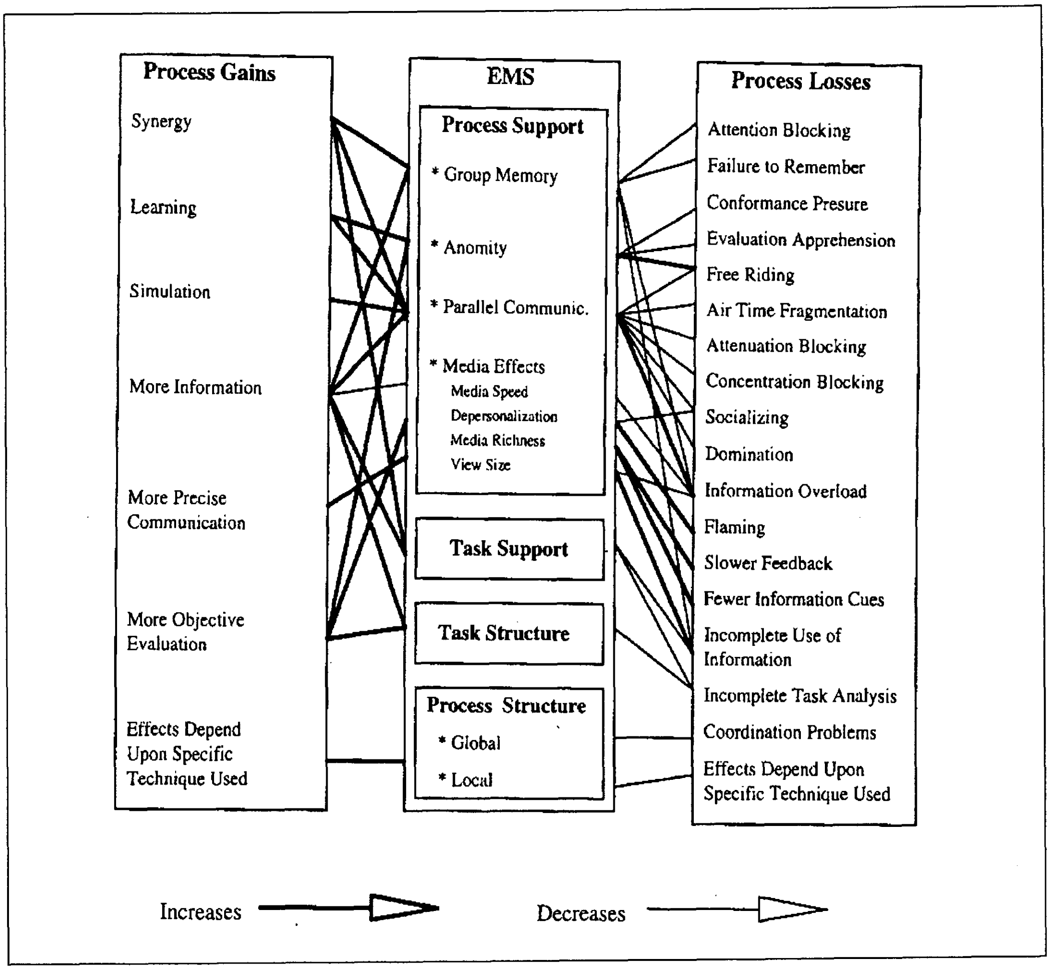

Figure 2.5 EMS effects.
(Source: Nunamaker et al., 1992, p. 144.)

Researchers in the University of Arizona concluded that each of the above mechanisms could reduce some process losses and increase process gains in some way. Their conclusions on process gains and losses were based on their EMS empirical studies. Those experiments were conducted in a decision room, which means it was a synchronous setting and always gave subjects only limited time to work on their task. However, asynchronous group decision-making might be a different story. Further discussion on the relationship between communication modes and process losses and gains will be given in the next chapter.

2.7.2 Effects of Communication Structure – Discussion

Pinsonneault et al. (1999) compared four types of brainstorming technology (verbal, nominal, anonymous EBS, and non-anonymous EBS) in terms of process gains and losses. They calculated the net sum of the process gains and the process losses to compare these four technologies. Stenmark (2000, 2001) extended their analysis on comparison of those technologies in a more comprehensive list. The following tables (Table 2.3(a), Table 2.3(b)) presented the results of their comparison. However, the communication structures are not limited to the above four types. All possible communication structures need to be compared in terms of process gains and losses. According to contingency theory, there will be no system or communication structure which will increase all the process gains and eliminate all the process loss. However, compare all the categories can give researchers a better understanding of the characteristics of each structure. Moreover, it can guide people in selecting the best communication structure to fit their communication needs.

Table 2.3 Comparison of Four Types of Brainstorming Technology (Source: Pinsonneault et al., 1999; Stenmark, 2000, 2001)

(a) Comparison in Process Gains

Process gains	Verbal	Nominal	Anonymous EBS	Non-anonymous EBS
Separation of task		+	+	+
Cognitive stimulation	+		+	+
Observational learning	+			+
Social recognition	+			+
Task Orientation		+	+	+
Motivational	+	+	+	+

(b) Comparison in Process Losses

Process Loss	Verbal	Nominal	Anonymous EBS	Non-anonymous EBS
Production blocking	-			
Effort redundancy		-		
Cognitive interference	-		-	-
Cognitive inertia		-		
Evaluation apprehension	-			-
Productivity matching	-		-	-
Cognitive conformity	-			-
Personalization of issues	-			-
Social influence	-			-
Social loafing	-		-	
Attentional blocking			-	-
Striving for originality			-	-
Cognitive complexity			-	-
Cognitive dispersion			-	-

A more comprehensive list of communication structures includes:

- *Individual problem solving*: Since there is only individual effort, increasing the process gains will be difficult. But most group process losses are also at the minimum level, since there is nobody else to interrupt his/her thinking. It also has its own limitations – when facing complex problems, it is hard to completely use all the information and analyze the task by an individual.
- *Anonymous qualitative contributions*: Cognitive bias, such as anchoring and adjustment, conservatism might occur.
- *Anonymous voting*: This can reduce the domination, but if it is only one time, the task might not be completely analyzed. Group members might not realize where the disagreement comes from. It also depends on different voting mechanism.
- *Information structuring*: Easy to understand the information. However, it depends on whether the correct structure to present the information is selected. If group members do not know which or how to choose the structure, the performance of the task will be reduced.
- *Synchronous group mode:* one of the biggest problems the synchronous groups have is the limited time period. Because of this, most synchronous groups suffer from production blocking, airtime, and free riding, etc.
- *Face-to-Face unstructured groups:* as compared by Pinsonneault et al. (1999) and Stenmark (2000), this kind of communication can increase cognitive stimulation, observational learning (if there are experts among other group members), social recognition, and get motivated. In addition to the common

problem the synchronous groups have, it also suffers from evaluation apprehension (no anonymous or nickname can be used), productivity matching, cognitive conformity, personalization of issues, and social influence.

- *Structured face-to-face groups*, such as nominal groups, focus groups, etc. The process gains and loses has been presented in the above tables.
- *Face-to-Face computer supported groups*, such as groups using GDSS/EMS. The process gains and loses has been presented in the above tables.
- *Asynchronous group modes:* Since group members in asynchronous groups do not have so tight time limitation as synchronous groups do, the production blocking, cognitive interference, cognitive inertia can be reduced or eliminated.
- *Mailing list: T*he most formidable process loss is information overload, where users receive such a large amount of unwanted junk mail that useful items are lost (Hiltz and Turoff, 1985; Palme, 1984). Also, there is no easy way to reuse the information in the message or trace the history of a conversation due to lack of structure. The proposed solution to these problems is to add filtering tools, or use moderator to facilitate the distribution of the message.
- *Group bulletin boards* (discussion threads): Work well for open-ended discussion with little to no organization or specific intended outcome.
- *Traditional Delphi* (paper and pencil): most process losses can be reduced or eliminated by using multiple rounds, anonymity, and a less restrictive coordination mode.

- *Automated Delphi* (Computer supported): As in traditional Delphi, most process losses can be reduced. Moreover, it can increase the effectiveness of the process by automate the coordination.
- *Asynchronous CMC/GDSS:* Anonymous and/or nickname can be implemented to reduce those losses related to the social presence. It can also increase the feeling of social recognization by using nickname.

2.8 Conclusion

The model shown in Figure 2.6 is an integrated framework of the reviewed models. In this framework, a GDSS is a mechanism to obtain benefit from using it. A GDSS cannot be regarded only as a tool. User should be also considered as a part of the system. User requirements should not be ignored.

A GDSS is meaningful only if it can improve productivity, increase process gains, and reduce process losses. Keep this in mind; flexibility of the GDSS will be desirable to fit the different users' characteristic. Different groups can tailor the GDSS to fit their needs for the task. However, sometimes users may not even know which kinds of structure/system features are most appropriate for their task. They might tailor a system in a way that even increase process losses. Therefore, different options and their possible outcome should be explained to users in advance, and user training will be needed if the system is used for solving very complex problems.

Coordination is another very important factor when people are trying to carry out certain tasks. According to task technology interaction theory, when coordination mode is set, the technology used to achieve the goal will be impacted. In group decision-making process, coordination is crucial for the success of the task. In synchronous mode, one can have an agenda available for every group member to complete a task. Group members can remind each other on where they are. However, in the asynchronous mode, this is not true. In asynchronous group communication, group members may be working on different paces. Therefore, a group faces more process loss opportunity, such as coordination problems, which will affect the performance of the group. How to choose a suitable coordination mode to make groups utilize the advantages of asynchronous communication to improve process gains while reduce the process loss is critical.

According to various task types, user requirements for coordination mode and technology also may vary. Once the coordination mode is set, the technology that supports users to do the task can be selected accordingly. Meanwhile, the way of using the technology can be tailored by users. The way of using the technology may be adjusted by users as their experience on the technology increases. Having a technology and coordination mode fit in the group process, groups will get better outcomes in terms of increased decision quality, increased process gain, decreased process loss, increased satisfaction to group process, technology used, and the solution.

This research focuses on the design and evaluation of a possible structure that a web-based social decision support system toolkit, a List Gathering Tool in particular, may provide to groups to solve a complex problem (a type 4 task according to McGrath's model). Therefore, given a fixed task and a parallel coordination mode to fit the nature of the asynchronous communication structure, the requirements of the tool will be determined. Based on the literature review and users' feedback (through "protocol analysis"), the author designed and implemented a List Gathering Tool. Groups are expected to adjust the way of using it as their experience increases. As the result, the improved decision quality, the improved satisfaction, the increased process gains and the reduced process losses are expected. From this research, the author tried to get a better understanding of the requirements of this kind of tool and to see the impact of such a tool on the group decision-making process. The detail of the tool design and results of this research are presented in later chapters.

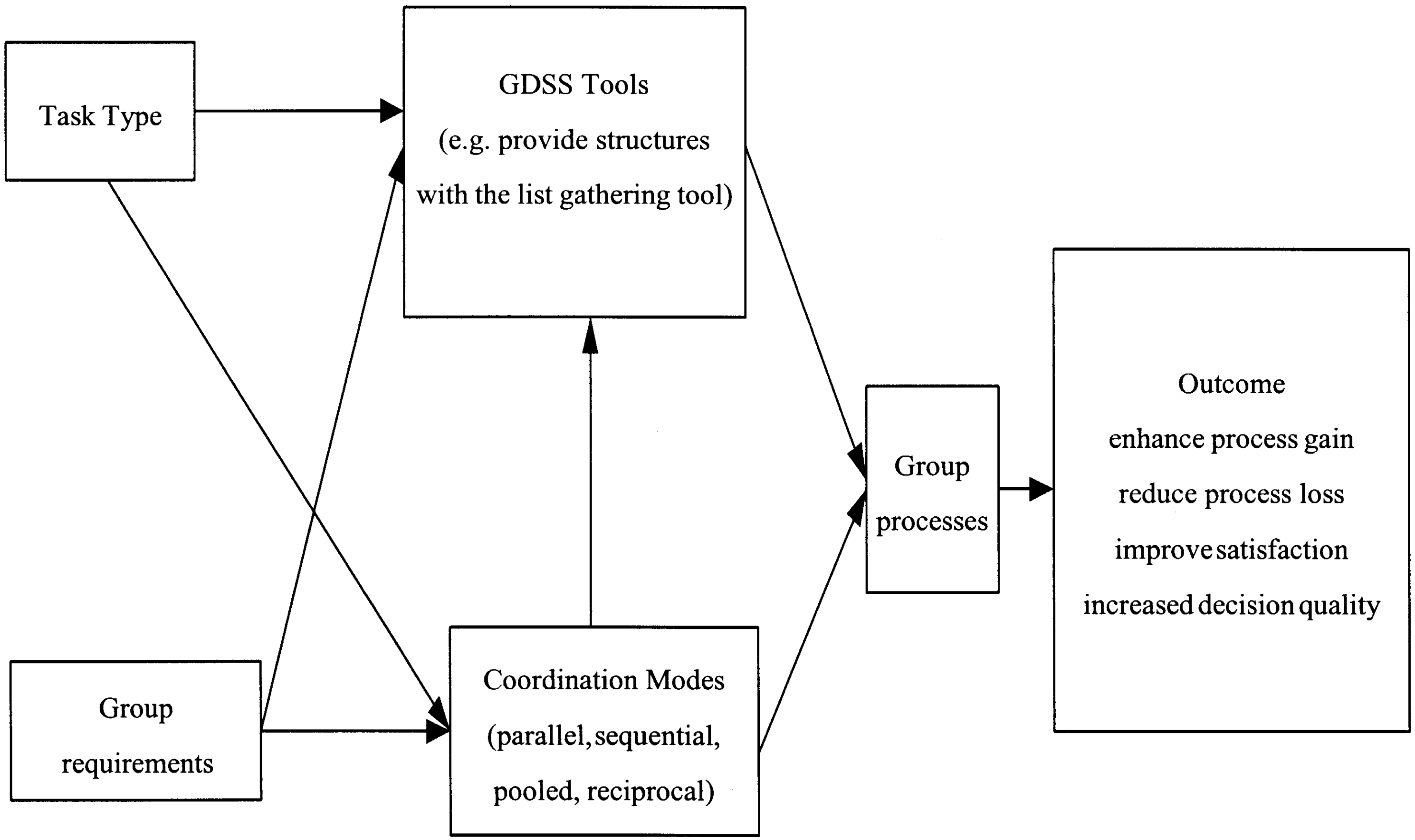

Figure 2.6 Integrated framework for Group Decision Support Systems(GDSS).

CHAPTER 3

LITERATURE ON LIST GATHERING PROCESS

As discussed in chapter one, "list(s)" of items is the foundation of analyzing the problem, especially for complex problems which involve many people. Possible lists (Turoff, 1991) are, but not limited to, goals, objectives, criteria, problems, issues, tasks, solutions, options, comments, relationships, contributions, plans, questions, strategies, policies, agendas, approaches, concerns, arguments, assumptions, viewpoints, values, interests, consequences, scenarios, impacts, tradeoffs, compromises, proposals, solutions, allocations, decisions, projects, etc. As such, how to get the right list and find out the relationship among items/lists is critical for solving the problem. Therefore, researchers need to look into the history of the efforts on getting "list(s)" to find out a better way to collect, organize, and present the lists of items.

In this chapter, a brief review of the efforts on getting lists is presented. These efforts include Electronic mail, Electronic Bulletin Board, Brainstorming (Osborn, 1957) and Electronic Brainstorming, Nominal Group Technique, Delphi (Linstone and Turoff, 1975) and Computer-supported Delphi, Agendas, Dialectical (Plan and Counter-plan), Devil's Advocate (Plan and critique), Focus Groups, etc.

3.1 Brainstorming, Electronic Brainstorming and Electronic Meeting Systems

Brainstorming is introduced by Osborn (1957). The objective of this process is to generate a full list of possibilities. The basic rules applied in this structure are: (1) Criticism is ruled out. Adverse judgment of ideas must be withheld until later. (2) "Free-wheeling" is welcomed. The wider the idea, the better. (3) Quantity is wanted. The more ideas, the better. (4) Combination and improvement are sought. In addition to contributing ideas of their own, participants are asked to suggest the improvement of others' ideas (modify or extend). Human facilitator is required in this process. The result of the brainstorming usually largely depends on the facilitator. There are some variations of brainstorming. For instance, some groups use "group writing". They ask group member to write down their ideas on a card and collect them into a group list. Then, discuss each idea. Most group writing process were using anonymous.

Electronic Meeting Systems (EMS) is defined as "an information technology-based environment that supports group meetings, which may be distributed geographically and temporally"(Dennis et al., 1988). In this system, "the IT environment includes, but is not limited to, distributed facilities, computer hardware and software, audio and video technology, procedures, methodologies, facilitation, and applicable group data. Group tasks include, but are not limited to, communication, planning, idea generation, problem solving, issue discussion, negotiation, conflict resolution, systems analysis, and design, and collaborative group activities such as document preparation and sharing."

Group process and outcomes, methods, and environments are three main parts in EMS; EMS is activity-driven. By using toolkits, collections of specific tools that address various parts of the meeting's process, flexibility of the system can be enhanced. The tools in the toolkits can easily be mixed and matched to achieve different goals of the group. The toolkit may include: agenda, session director, electronic brainstorming, issue analyzer, voting, topic commenter, policy formation, organizational infrastructure, stakeholder identification and assumption surfacing, and alternative evaluator, etc.

In electronic brainstorming, a moderator starts the session by sending the topic to each individual in the group, who then simultaneously type ideas into a computer. The individual's contribution is sent into a central pool, and an idea from this central pool is picked at random and sent to the screen in front of an individual, who in turn can use this as a seed for generating another idea. All contributions are anonymous to prevent evaluation apprehension. The sharing of ideas through the process of sampling and sending from the growing central pool is a guard against cognitive inertia. The fact that everyone can be entering ideas concurrently overcomes production blocking (Hymes and Olson, 1992). Electronic brainstorming process provides parallelism, which is the ability for all participants to enter information at the same time; group memory, which is the ability of sharing ideas by using computer screen, without production blocking, and anonymity (Dennis, 1996). This process combines the aspect of the nominal group process (being able to generate ideas at will) and the aspect of the traditional brainstorming process (being able to share ideas with others).

A lot of research has been done in electronic brainstorming system. Various laboratory experiments have been conducted to study the impact of brainstorming systems in different directions. Some researchers did research comparing the impacts of electronic brainstorming when using different group size; some researchers did research to find out the impact of anonymity in electronic brainstorming, etc. Gallupe et al. (1992) conducted two concurrent experiments with two-, four-, and six-person groups in one and six-and 12-person group in the other, in order to compare the number and quality of unique ideas generated by groups of each size using electronic and verbal brainstorming. Among the problems in brainstorming by large groups, they concerned on production blocking and evaluation apprehension. Their results showed that technology did not significantly improve productivity when there was no anonymity in small groups (the 2-person groups), but it did significantly improve productivity in large groups. However, the study conducted by Gallupe and his colleagues (1991) indicated somewhat contradictory findings to the previous belief that electronic brainstorming system's advantage is due to reducing of production blocking. In their experiment, electronic vs. non-electronic groups and nominal vs. interacting groups were compared in a two by two factorial design. The results showed that although computer technology did increase the productivity of four-person brainstorming groups compared with face-to-face brainstorming groups, the same was true for nominal electronic groups compared with their non-electronic counterparts. This result indicated computer technology itself does make difference, but not improved process.

Dennis and Valacich (1993) compared the performance (the number of unique ideas) of electronic brainstorming groups with nominal groups, in terms of different group sizes. They found that larger electronic groups generated more ideas than the larger nominal groups. However, there were no differences between the smaller groups. Therefore, the widely observed finding that nominal group brainstorming is superior to interacting group brainstorming does not apply to larger electronic groups. They suggested two possible explanations on why smaller electronic groups did not outperform their nominal counterparts, while larger electronic groups did outperform their nominal counterparts — synergy and redundancy avoidance. Members of larger electronic groups (12-person groups) generated more ideas per person than did members of smaller groups (six-person groups). The authors stated that synergy requires a critical mass of ideas before it has a significant effect because interaction has an overhead cost: participants in electronic groups must read and think about ideas before those ideas can stimulate new ideas, whereas members of nominal groups can continue to generate ideas without pause. Further analysis showed that another reason for differences in the number of unique ideas per person is that nominal groups generated more redundant ideas, whereas electronic groups used the group memory to avoid duplications. Theses results suggest that performance effects occur because electronic brainstorming introduces no more process losses than does nominal group brainstorming (e.g., blocking, evaluation apprehension, and free-riding) while enabling process gains (e.g., synergy and redundancy avoiding) and these effects occur in larger groups.

Aiken et al. (1994) also did an experiment comparing Face-to-Face verbal groups with groups using GSS support in terms of different group sizes. They found that the electronic brainstorming is superior to verbal communication in large groups for idea generation. The production blocking and evaluation apprehension were higher in face-to-face mode than in GSS mode. These results show the effects of the technologies in the groups – an electronic meeting system can help to prevent production blocking and evaluation apprehension.

All of the above studies found that large groups (nine to 18 members) generated more ideas when using electronic brainstorming systems than the counterparts of nominal groups. However, there are some limitations of the Arizona group's electronic brainstorming studies. Hymes and Olson (1992) pointed the fact that: (1) not all studies have proved the electronic brainstorming technique's advantage over nominal groups; (2)

the effect of computer technology confounded with the effect of different group structures.

From the description of the experiments conducted for studying the electronic brainstorming, the following limitations are presented: (1) Most studies gave subjects very short time period to perform the task, for example, different studies conducted by Valacich et al. (1994) gave subjects 30 minutes, 15 minutes. This is definitely too short for subjects to carefully think about the task; (2) Most studies used ad-hoc groups, however, in real world, structured groups are often used in Nominal group technique and Delphi study; (3) The nature of the problem used in experiments were mostly too simple and lack of motivation; (4) Most studies were conducted synchronously, which limited the time for subjects to deliberate.

Hymes and Olson (1992) examined the ability of a simple, unstructured parallel editor to facilitate idea generation in face-to-face groups. Their results showed that parallel interacting groups outperformed serial interacting groups, and parallel interacting groups did not significantly differ from nominal (non-interacting) groups. These results suggested that an informal tool that allows parallel work is an effective way to increase idea generation in real interacting groups.

3.2 Nominal Group Technique

Nominal Group Technique (NGT) was designed as a means of formally structuring and channeling face-to-face discussion to reduce communication problems commonly experienced in groups (Reagan-Cirincione, 1993). It involves the following processes: Individual work separately, silently write down his/her ideas, then work as an interacting group using round-robin participation (each individual take turns to present one idea each time) until there is no more new ideas. Each idea is then discussed individually by the group, followed by spontaneous evaluative discussion and voting. There are some variations. For example, a group can be divided into two or more nominal groups working independently, then present their final set of ideas to the whole group, work on it again and vote on the final joint list.

Gallupe et al. (1991) reported that brainstorming groups do not outperform their nominal group counterparts and the marginal productivity of members of brainstorming groups declines as groups grow larger. This is partly due to the production loss the brainstorming groups suffered, as discussed in the previous chapter.

3.3 Delphi Process and Computerized Delphi Process

3.3.1 Delphi Process and its Characteristics

Linstone and Turoff (1975) defined Delphi from the group communication's viewpoint: "Delphi may be characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem." The basic objective of Delphi is the design of communication structures to coordinate information exchange in asynchronous problem-solving groups. Delphi was commonly applied utilizing a paper and pencil communication process among groups in which the members were dispersed in space and time. This methodology is often used for complex, unstructured problems, such as trying to predict potential breakthroughs in biomedical research and their societal impacts.

Usually Delphi has four distinct phases (Linstone and Turoff, 1975):

- Exploration of the subject under discussion, each individual contributes additional information he/she feels is pertinent to the issue.
- The process of reaching an understanding of how the group views the issue (for instance, where the members agree or disagree). If there is significant disagreement, the disagreement is explored in the next phase.
- The process of bringing out the underlying reasons for the differences and possibly to evaluate them.
- Final evaluation after all gathered information has been initially analyzed and the evaluations have been fed back for consideration.

Characteristics of Delphi are as follows:

- **Asynchronous communication**: Delphi method allows group members to participate in an asynchronous manner. Group members can choose to participate in the group communication process when they feel they want to. They may also choose to contribute to the problem to which they feel best able to contribute.
- **Coordination mode:** in Delphi process, a less restrictive coordination mode can be applied. Instead of forcing groups to take a sequential path through a group problem solving process, Delphi process allows any individual to choose the sequence in which to examine and contribute to the problem solving process.
- **Anonymity**: By allowing the individual group members the opportunity to express their opinions and judgments privately, undesirable social pressures,

such as dominant or dogmatic individuals or from a majority, could be avoided.

- **Exploration of Disagreement**: Voting is used to explore disagreement among group members, rather than reaching premature consensus. Items, in which most of respondents agree upon, could be removed from further discussion.
- **Balance between Quantitative and Qualitative Evidences***:* In addition to a statistical summary of group response, arguments for underlying reasons used by group members to support their views are fed back to the group.
- **Iteration and Feedback***:* By giving several rounds, individuals are given opportunity to update their views based on the group judgments and underlying reasons behind those judgments. They are usually requested to add additional issues that were evolved from the feedback.

3.3.2 Previous Delphi Application Example

Turoff proposed Policy Delphi in 1970. The objective of Policy Delphi is to generate the strongest possible opposite views on the resolutions of major policy issues. The policy Delphi assists people analyze policy issues by making informed group present all the options and supporting evidence for their consideration. By exploring all the differing positions or understanding the underlying reasons, assumptions, views, and facts used by others to support their respective positions, the respondent group can understand the true nature of the complex problem. The Policy Delphi can be used with other methods such as a committee, functioning as an organized method for correlating views and information pertaining to a specific policy area and for allowing the respondents representing such views and information the opportunity to react to and assess different viewpoints.

The structure of Policy Delphi is done by the following six steps: (1) Formulate the issues; (2) Expose the options for the given issue; (3) Determine initial positions on the issues such as, "Which are the ones everyone already agrees upon and which are the unimportant ones to be discarded?" or "Which are the ones exhibiting disagreement among the respondents?" (4) Explore and obtain the reasons for disagreement (What underlying assumptions, views, or facts are being used by the individuals to support their respective positions?); (5) Evaluate the underlying reasons; (6) Reevaluate options, based upon the views of the underlying "evidence" and the assessment of its relevance to each position taken (Turoff, 1975). The respondent group expresses ideas and those items that are assessed using scales such as relative importance, desirability, confidence, and feasibility. A policy issue is generally assessed on desirability and feasibility. The items which most respondents have already agreed upon can be removed from further discussion. New options may be generated by discussion among respondents from the items which are rated against desirability and feasibility scales. The respondents are asked to provide their underlying evidences on the controversial issues (issues which have shown strong disagreements among respondents) and these evidences are usually evaluated with respect to importance and validity or confidence. After the votes are taken, the statistical summary for each item is provided to the respondents. In case of polarized views on certain items, a correlation analysis between this polarization and the affiliation or backgrounds of the respondents is usually performed.

3.3.3 Computerized Delphi Process

In most cases, experts involve in a Delphi study are always geographically dispersed. Thus, the most important property of the Delphi method is the ability of members of a group to participate in an asynchronous manner. Therefore, participants need to wait for a long time from they filling out the survey form to getting the summarized result and start a new round of thinking on the problem in a conventional Delphi process. This also increases the difficulty for researchers to conduct the study. The researcher in Delphi study plays a "facilitator" role. Computerized Delphi system can help to keep the advantages of conventional paper-and-pencil Delphi process while improving the way of facilitation.

It is easier to give group members ability to choose their own sequence to solve the problem in a computer system compare to traditional paper-and-pencil based Delphi studies. In traditional Delphi study, a "round" structure limits the flexibility of the study – the size of study and the coordination mode are constrained. In computerized Delphi study, complete parallel entries to any aspect of the problem are allowed. The "round" structure may disappear in a computerized Delphi process by implementing a continuous feedback process which may or may not involve human intervention for the processing (Turoff and Hiltz, 1995).

Although in traditional Delphi process, anonymity can be achieved by not giving identification of who contributed specific material or who made a particular evaluative judgment about it. In a computer system, this may be accomplished very easily. However, anonymity should not be over used because it is very important that the members of a Delphi study believe that they are communicating with a group. An individual can be motivated to participate only if he/she can feel that the other members of the group will be able to contribute valuable insights (thus self-rated expertise) about the problem being examined. Therefore, different forms of anonymity can be implemented in a computer based Delphi system.

Hiltz et al. (1989) studied the impact of penname in a computer conferencing system. By using pennames, it allows a person to be identified with a set of related contributions while not identify who that person is. This may help group members to have a feeling of why a certain individual has certain opinions.

In a computer based Delphi system, it is also very easy to provide the ability of allowing participants to freely choose when they want to use pennames, when they want to use anonymity, and when they wish to discover their real identity to the group.

In a traditional Delphi study, the coordinator of the study needs to integrate contributions from participants to give a summary to the group. In a computer based Delphi system, an individual member can update his/her contribution during the process. They can decide whether their opinions are new before making a contribution. Therefore, the amount of duplication will be minimized in this system.

The core of a Delphi process is the structure that relates all the contributions made by the individuals in the group and which produces a group view or perspective. In a computer based Delphi system, the structure is one that reflects continuous operation and contributions. Instead of dividing a structure into several discrete rounds as in paper-and-pencil based mode, a computer-based Delphi can allow participants contribute to different lists at any time. The computer's role in this process is to organize everything so that the individual can follow what is going on and obtain a group view:

- Provide each member with new items that they have not yet seen.
- Organize lists of arguments about any resolution.
- Allow the individual to view lists of arguments according to a specific criterion (by keywords, voting scales, etc).
- Allow the individual to compare different arguments.
- Provide status information on how many respondents have dealt with a given resolution or a list of arguments.
- Minimum the role of the Delphi coordinator because the software can give the power to an individual special privileges to manage discussion. Also, software can handle some of the management function automatically if there is a set of rules.
- Tally the votes and make the voting results viewable to participants when it is available.

Furthermore, Delphi system can be also viewed as a representation of a specialized Hypertext system (Conklin, 1987; Nelson, 1965). Hypertext system views text fragments in a computer as the nodes in a graph or web of relationships making up a body of knowledge. Computer-based Delphi system can help groups to build semantic relationships among items and are being utilized for browsing and presenting content oriented groupings of the material. Therefore, Hypertext functionality will be useful if it is implemented in a computer based Delphi system.

3.4 Discussion

This chapter reviewed several group process structures which are the efforts of getting the "list" for the foundation of problem solving. The author also reviewed the characteristics of a Delphi process and how the computer based Delphi system can help groups in the problem solving process by providing computer support in terms of different mechanisms to support anonymity, process structure, etc.

Electronic meeting systems help groups to increase process gains and reduce process loss by providing parallelism, group memory, and anonymity.

This chapter presented several key issues in helping groups in their problem solving process in an asynchronous computer communication environment:

- *Less restrictive moderation mechanism* – not forcing groups to use a certain sequence to solve the problem. Give groups flexibility to make decision by themselves
- *Different user identification mechanism* – penname, anonymity, and real name
- *Group memory* – providing both group idea storage and retrieval ability
- *Group size* matters
- *Parallelism* – group members can contribute at the same time to reduce production blocking, etc.
- *Role management* – assign users different privileges by a coordinator or by software automatically according to a set of rules.

Having the awareness of the above issues in mind, a look at the current implementations of different list gathering activities in voting tools to support group problem-solving process and access how well each meets the above requirements is needed. Next chapter reviews the implementation of some selected systems.

CHAPTER 4

CURRENT TOOS IMPLEMENTATIONS

Currently a lot of group decision support systems, such as the University of Minnesota SAMM system, the Capture Lab in Michigan, the University of Arizona spin-offs GroupSystems, TeamFocus by IBM, and VisionQuest by Collaborative Technologies Corporation, are available. Those systems consist of a number of different tools that are intended to assist in aspects of the group decision-making process. These tools have evolved over the years as a result of experiences of use. There is support for brainstorming activity – to get the right "list" to work on, for ranking alternative choices and voting on them, for preserving anonymity, etc. Although the "list" is the foundation for all the voting process, not all systems support the activity of gathering a list. Only moderators can generate a "list". Moreover, most of the systems are only available to synchronous mode only. This chapter reviews a selected list of tools. Some of these tools are for research purpose and have been reported in research papers. Some of these tools are currently available online or as a commercial package which seems promising.

4.1 Current Tools Implementations

Electronic Meeting System by the University of Arizona. The Electronic Meeting System (EMS) developed by University of Arizona has a software tool that supports idea generating, and gives priority two each idea in the idea-generating list. (Nunamaker et al., 1991).

GroupSystem Electronic Meeting Software by Ventana East. GroupSystems is a comprehensive set of group problem-solving tools that runs on interconnected personal computers. From issue exploration to final decisions, it provides structure and focus for team's collaborative efforts. GroupSystems is a relatively sophisticated problem solving tool implementation. It provides software tools that support the following functions:

Idea Generation is a process designed to create a list of possibilities. Idea generation includes creative, inventive activities where the ideas generated are new or being combined in a new manner. This tool allows groups working simultaneously to build a list, add comments to list items, and move and copy list items to specific categories.

Below is a screen shot of the GroupSystem's Idea Generation tool:

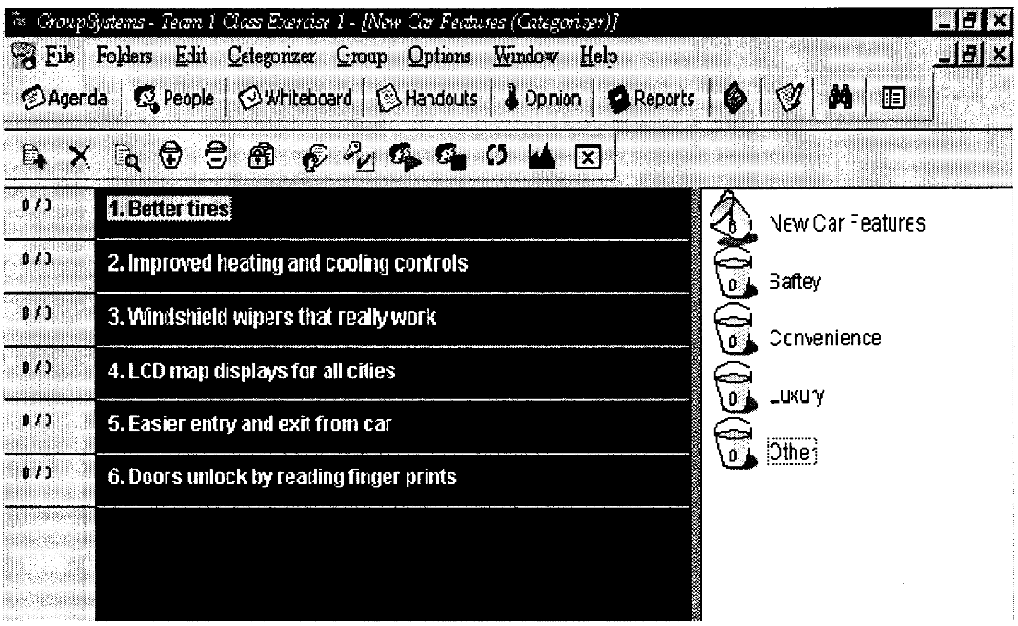

Figure 4.1 GroupSystem's idea generation tool interface.

Idea Organization is a process that results in a shorter or less diverse list of items. The process involves taking previously generated information and refining, rearranging, or consolidating the items based on some organizing principles.

Idea evaluation determines the degree of consensus on a set of alternatives. Groups often work together to determine consensus, discuss results, and then re-evaluate the alternatives. Questions or alternatives are rated and the relative value of those items in relation to each other or to an external item or condition is determined.

Issue Analysis and Exploration clarifies issues, and develops a deeper understanding. Relationships between issues are also explored.

Information Management supports the dissemination of the data and information developed by the group. It supports storage, management, and retrieval of materials.

List and Voting Tool in EIES2 by New Jersey Institute of Technology. Dufner (1994) developed list and voting tools in Electronic Information Exchange System (EIES 2) in New Jersey Institute of Technology. These tools are designed for use within a conferencing environment. They are designed to work together. Three types of voting activities are supported in this system. They are: vote for one item on a list; vote yes or no to each item on a list; rate each item on a list. Before voting, a "List" activity is performed to create a list of related items for evaluating. Users can create list activity as an attachment to a conference comment, or to be a new item in the conference. The system allows users to change their vote before submitting to the system. It also allows user to view group voting results. EIES 2 keeps track of associated comments by creating a hierarchical linked list for retrieval purposes. Users are able to monitor their own progress by checking the status to see whether there are waiting items. However, this system is not Web-based.

Voting Tool in TCBWorks by Terry College of Business, University of Georgia. Terry College of Business at the University of Georgia developed one Web-based GDSS called TCBWorks. It also allows voting on Topics. In their system, voting is done with a simple spreadsheet or matrix (maximum of 10 columns as criteria). The voting screen allows users to vote on Topics and to modify the appearance and criteria used in the voting procedure. The criteria – list of criterion -- are defined by the users (or the project organizer) and can be changed easily. Votes may be changed at all times. The voting results can be displayed in a variety of different ways. Only one vote is permitted for each user-name, so if more than one person is using the same user-name, the votes will not be calculated correctly. It also allows users to see the average ratings for the entire group. The Topics are listed in order in the box below the Project. The first column will show the average across all criteria (if there are more than one criteria) and the next columns will show the average rating on each criterion for the entire group. The Vote Options Screen allows users to change the names and ranges of the Criteria as well as the format of the boxes. Users can change the order of Topics on the Voting Screen and Group ratings screen as well. They are given the choice on which criteria will be used to sort the topics, they are:

- Original Topic Order: the order of the Topics from the Project Screen.
- Average across all criteria: sorted by average.
- Each Criteria: sorted by the values of the first, second, third criteria, and so on. You can choose to sort by any of the criteria that you are using.

The COCA Model. COCA (Collaborative Objects Coordination Architecture) is a generic framework for developing collaborative systems, it contains a modest set of tools for electronic meeting systems (EMSs) to show how they can be used to support both unstructured and structured meetings, with only changes in the coordination policies and no changes to the tools themselves (Li et al., 1999). A distributed whiteboard tool called *coboard* helps users to share their ideas by drawing free-hand, line, rectangle, oval, text, image, an awareness tool *roster* lists all current participants in a collaboration, a voting tool helps multi-users decide whether or not they can control an item within a meeting, a bulletin board bulletin displays the voting results, and an alerting tool alert provides reminder to users.

Workplace Voting Tool by TeamWave Software Ltd. This voting tool allows group members to vote on simple yes/no questions. The question is entered at the top of the window. Each user can vote by pressing either the "yes" or "no" buttons at the bottom. But in this voting tool, there is no support for a group to collect a list to vote on. Only manager can create the voting questions.

Below (Figure 4.2) is a screenshot of the interface of this tool:

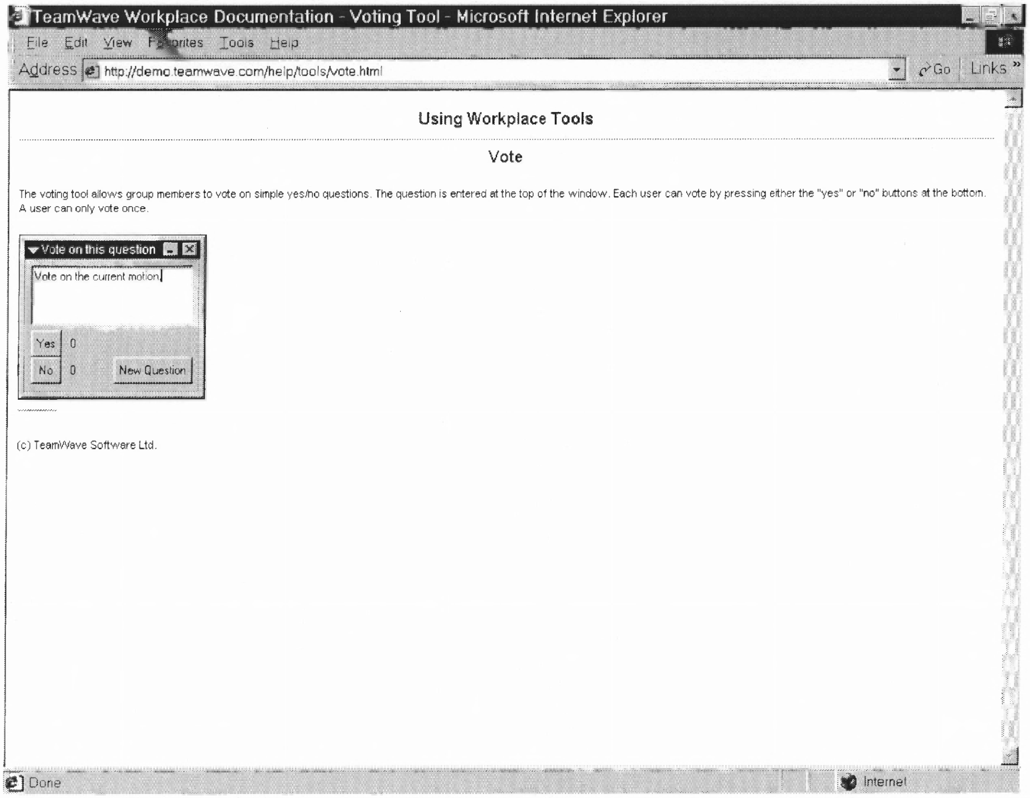

Figure 4.2 TeamWave software Ltd. workplace voting tool interface.

Voting Tool by DCN/ICN. Defense Collaboration Network/International Collaboration Network (DCN/ICN) developed several collaboration tools including comment/annotation tool, conference management tool, voting tool, etc. The conference management tool can only organize messages by threads. Even though their tool does not seem powerful enough for managing complex lists, they do give user flexibility to set their own preferences regarding to what kind of information to be displayed and how to display, etc. The way they handle users preference can be helpful to the researcher's interface design. Below is the screen shot of their option-setting window.

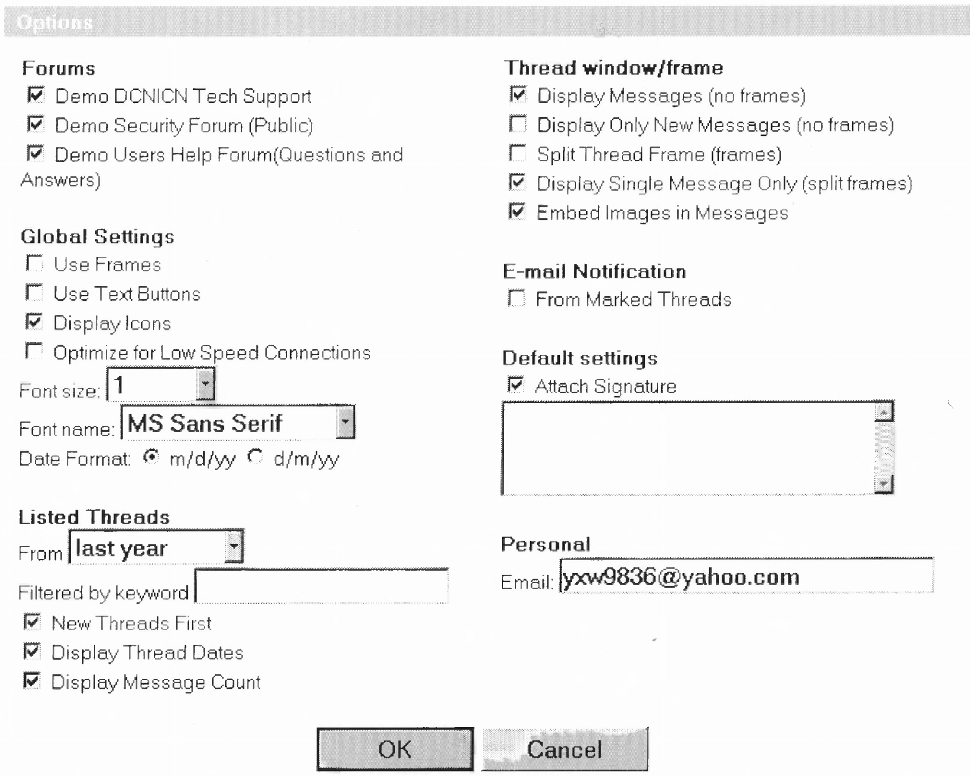

Figure 4.3 Screenshot of option-setting window in voting tool by DCN/ICN.

Voting subsystem in Web4Groups. A highly customizable voting subsystem has been implemented as a part of the Web4Groups EU supported project (Telematics Application Development Projects, Fourth Framework Program). The target of the Web4Groups project is to develop a distributed non-simultaneous (asynchronous) group communication system with multiple access possibilities (WWW, mail, fax, etc.) and incorporating advanced groupware functionalities such as voting, rating and annotation. They argued a general rating facility could be specialized from a general voting facility by inheriting all features in the voting tool and providing additional mechanisms for ranking the rated objects and for the association of rated objects to rating services. A voting is presented as a set of Web4Groups forums and messages. Special actions in a voting are shown as buttons when a user browses the voting. This way, user registration, access permission, message threads, multi-linguality and distributed behavior are inherited from the Web4Groups system. The voting subsystem is implemented as a plug-in module for the Web4Groups system. Their idea of a generally applicable voting tool (Biro et al., 1997; Kiss et al., 1997; Kovacs et al., 1997) controls voting processes according its configuration given by the vote organizer.

The configuration includes:

- Definition of user groups
- Definition of the questionnaire (vote form)
- Definition of the voting process

Participants may vote either by filling the questionnaire via the WWW interface, or by sending their ballots in e-mail. In this phase normally no interaction is needed by the organizers, but in case of disorders they have a possibility to interrupt and fix the voting process. According to the script invitations, reminders, results are generated automatically. Finally the voting process is terminated and the vote is closed. This process can be followed in the log (which is a message readable to all participants). After closing the vote, the workspace turns into an archive, storing all important documents of the vote.

Figure 4.4 is a screen shot of the interface of this tool.

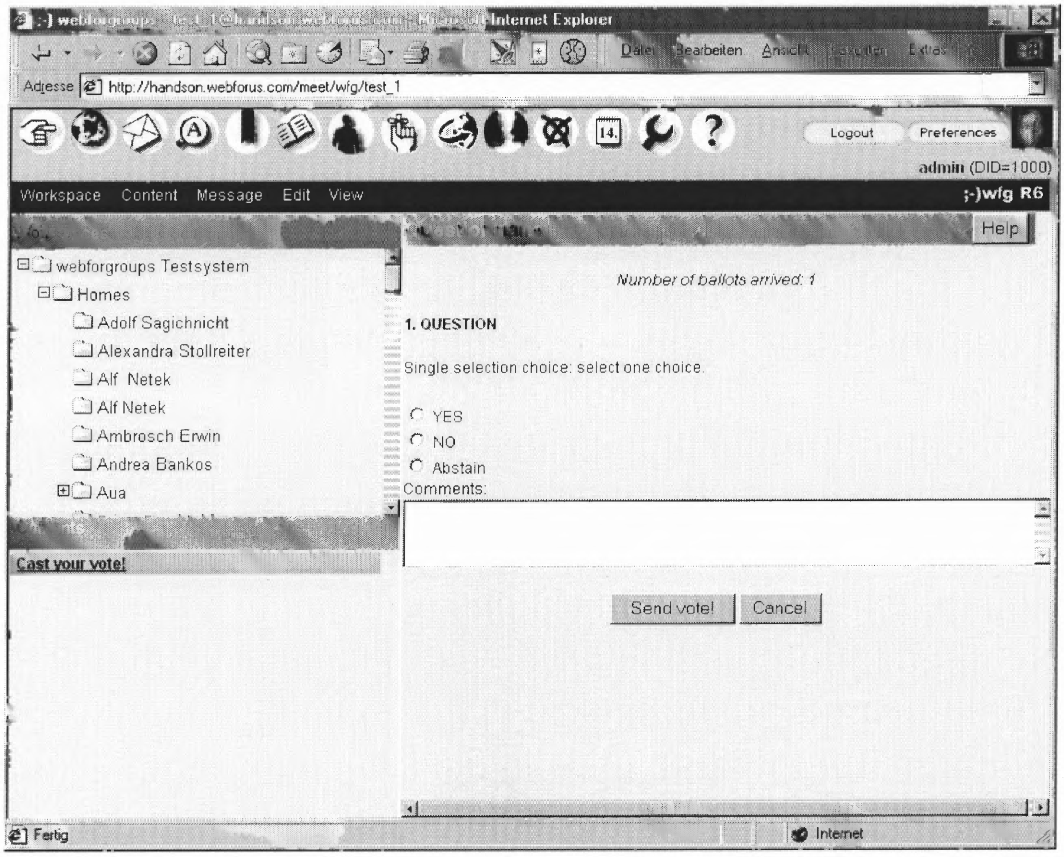

Figure 4.4 Screenshot of Web4Groups.

Consensus @nyWARE® by Soft Bicycle Company. Consensus @nyWARE® is a series of integrated Web-based, Java-enabled tools that allows teams to conduct high performance meetings, planning, visioning and decision support sessions on-line anytime, anywhere. This is the commercial version of TCBWorks. It provides a pretty comprehensive software package to support following applications:

Nominal Group Brainstorming (NGB) - Teams can build comprehensive lists of ideas for new products, projects, issue analysis, reorganization plans, strategic objectives, etc…

Multi-dimensional Brainstorming (MDB) - Sometimes people want to be able to collaborate on several ideas at once. MDB allows the organizer to establish multi-dimensional exercises to simultaneously collaborate on a variety of topics.

Rank Order Vote - Users can rank order a list of items including projects, actions in an action plan, business opportunities, etc.

It also supports some simple role control. For example, administrator, who has controls on all functions in the system including security, folder maintenance and access privileges; organizer, who can control project maintenance and access privileges, in addition to identity; and participant, who is assigned a user code and password for each and every folder.

They also use metaphors to represent different meanings of each comment. For example, "+" means "positive comments", "-" means "negative comments". Figure 4.5 is a screen shot of discussion window in this system:

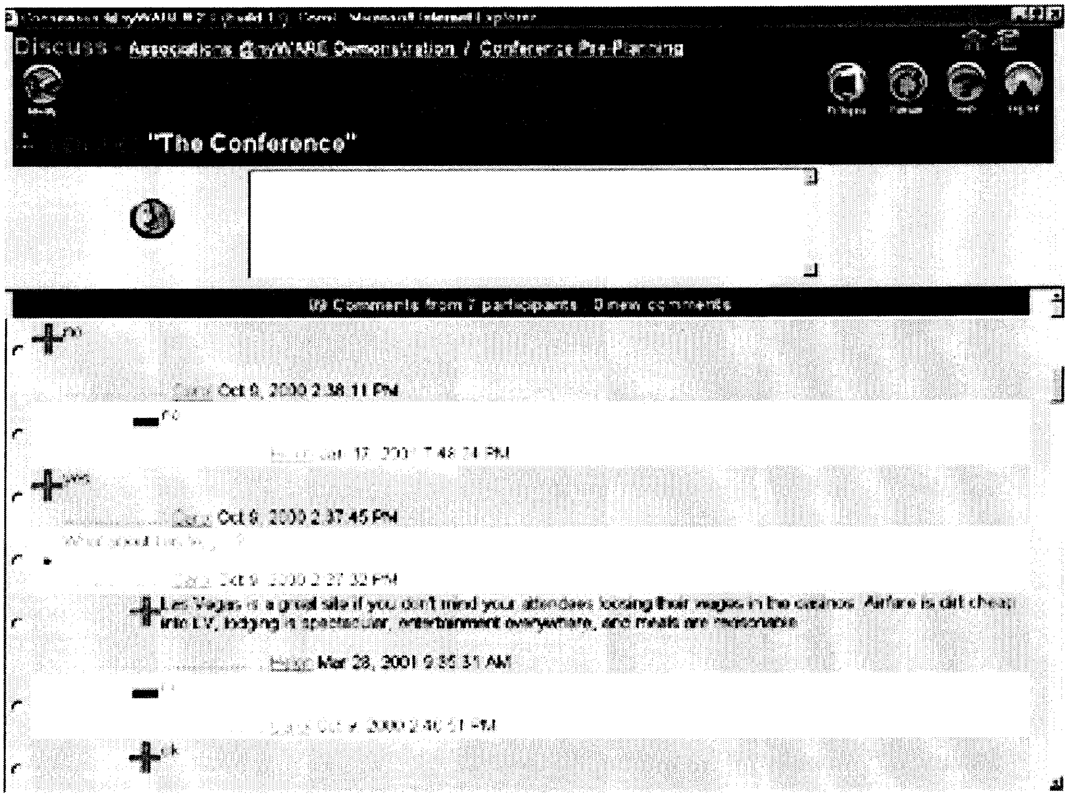

Figure 4.5 Screenshot of discussion window in consensus @nyWARE®.

4.2 Discussion

The above discussion presented the following problems of the current tools:

1. Although the activity of gathering a list is crucial for solving the problem, most systems only provide very simple functionality on getting items and their relationships, or nothing at all.
2. Even though some systems provide ways to gather ideas, it does not provide ability for users to identify the relationship between items.
3. Most of systems organize the items into a hierarchical structure, which is not true in most cases, especially in a very complex problem environment. This

problem hinders the groups in getting a full understanding of the information. Hence, it might lead the groups to sub optimal solutions.

4. Most of the systems reviewed are not available on the Internet. Although some of the above systems can be accessed from the Web, most of them do not have enough functionality to collect and organize ideas before and/or after vote. The descriptions of the above systems show that most systems either do not have the flexibility for group members to collect list of ideas to vote on, or only have a strict agenda for groups to work on. This is built on the theory that a decisio-making process is always roughly characterized as a series of steps, which include defining the problem space, listing alternatives within that space, assessing the consequences of each alternative, and finally selecting from among them (e.g., brainstorming-idea analysis-voting) (George & Jessup, 1997). However, information needs only become apparent in particular situation. There is a possibility that any group or individual problem solving process could occur in any order and at any time (e.g. vote might be cast at any stage). The system should be tailorable (Patel, 1999; Turoff et al., 1991). Therefore, it is necessary to view the functionality of a system as a set of tools, so that the group can adjust the use of the tools collectively, individually, or through the leader and/or meta communication support aids.

There are promising tools on the Internet as well. For example, "Consensus @nyWARE®" does have most functions – build a list, add items to the list, user role control, metaphor for different items, etc. -- that groups need in collecting and organizing ideas. To some extent, its interface design also seems very easy to understand, which can be helpful for researchers.

4.2.1 Requirements for Group Decision Support Systems

Bentley and Appelt (1997) studied the design of a Web-based groupware system. Their study indicated the need to support individual requirements of participants in group work, whose different environments, tasks and preferences may call for flexibility in the presentation of information, even when that information is drawn from a 'shared' space. They further indicated that collaborative systems "must be flexible in supporting different methods of controlling and granting access to information and that sharing often evolves over time." Finally, they argued that user feedback is critical in identifying problem areas in the system design.

Turoff (1991) reviewed the history of computer-mediated communications to support group-oriented activities. From Delphi conferences to EIES, the most important features are *tailorability, quantitative communication structures, content-based communication, indirect communications*, *roles*, and *notifications*.

One system must be flexible enough, so that system users can tailor the system as they wish in a specific environment. Most commercial systems are only work for the structures they are addressed to. That limited the use of the system. Some commonly available systems that allow users to customize are needed.

One GDSS must also provide a mechanism to allow users to communicate with and about numbers not just with words. They should be able to retrieve the historical data as well. Someone in the conference must be responsible to the maintenances of those values.

In a group decision support system, group members may also hope that the system have a communication tool so that the content of the communication item can determine where it is delivered. This kind of tool should be able to be attached to any quantitative or qualitative data item, which allows a discussion thread to take place associated with that item. This feature enables users to add group communication to any item they want to discuss.

Moreover, there should be some administrative functions, such as role management, notifications, etc. Role management means that each group member should be assigned to his own priority. For example, a group member with the "participant" role can only post his comments or read others comments in the conference; while a group member with the "manager" role can not only post, read comments in the conference, but change the status of the conference, delete comments posted by other group members, as well. Notification means that a system should have a way to inform group members the result of the action of other members of the group. For instance, a group member should be informed when a votable item has been established that they need to input his vote. These automated notifications are very important in minimizing the need of users to take unnecessary actions.

4.2.2 Requirements for Web-based List Gathering

The review of the literature on the theory and system implementation illustrated the importance of the list gathering activity in the decision making process. What methods/structures can a group use to collect all the items? How to help users find the relationship between items? How should the items be organized and presented? To what extent, can the group members have the ability to handle different items in the list? How can group members be motivated in the group process by using certain tools? Will the availability of the Web bring more advantages in getting the list? How will the Web-enabled tools affect group process? What kind of system can help group obtain more process gains while reduce/eliminate process losses or biases? These are the questions still need to be answered.

Previous discussion identified the following requirements for Web-based list gathering:

1. Administrative functions:
   - Role management – each group member has his/her own priority
   - Notification – inform the group member about the result of the action of other group members to improve users' awareness.
   - Status management – group manager can manage the status of each list.
2. Communication functions:
   - Access or add items at any time.
   - Create (semantic) links between related items no matter whether those items are under the same list. The list should not be only in a hierarchical structure. The items in the list might be inter-related with each other. Therefore, a network structure needs to be built for lists. As a starting point, a list of standard link types should be made available to users. Users should be able to select the type of link when they want to define the relationship between items, or they can define a new type of link and add it into the link type list for later use.
   - Retrieve historical items for current user for reference.

- Group members can see the activities taken by other group members.

3. Flexibility function requirements:

   - Group members can set their own preferences.
   - Group members can access any list as long as the list is not closed.
   - Group members do not need to follow a strict agenda to access lists.
   - Security issues should also be taken into account.

CHAPTER 5

LIST GATHERING TOOL DESIGN

5.1 Introduction

A Social Decision Support System (SDSS) is a type of inquiry system that supports the investigation of complex topics by large groups which hold many diverse and opposing views (Turoff, et al., 2002). The objective of developing a SDSS Toolkit is to help the individuals in the group to effectively produce, integrate, and synthesize their diverse views asynchronously (Turoff, et al., 2002). A List Gathering Tool is dedicated to producing collectively a list of items of a given type (e.g., goals, tasks, criteria, issues, etc.). The SDSS Toolkit has many features to enhance the group process so that:

a. All participants can come to respect and understand the differences caused by diverse values and interests of the contributing population,
b. A large population of participants may be accommodated,
c. There can be a movement towards consensus on at least some of the issues involved, and
d. There is limited need for human facilitation of the meta-process of communication which is replaced by dynamic voting processes.

As a fundamental part of the SDSS Toolkit, a List Gathering Tool helps group members to organize their ideas into a manageable list with a clear structure. Group members can collaboratively build a list and organize the discussion as items in the list. Instead of using a simple post and reply structure in the general conferencing system, a contribution can be not only the users' original thoughts on a discussion topic, but also a suggested replacement for a number of other items on the list (e.g., consolidation), or a comment on an existing idea.

The Dynamic Voting Tool is not a simple tool that just provides majority voting or simple ranking, but integrates several major voting and scaling methods. It supports "yes/no", rank order, Likert scales, semantic differential scaling methods, and different voting methods such as plurality voting and approval voting. The major feature of the Dynamic Voting Tool is to provide human dynamic voting. That is, during a group process, group users can change their minds and change their votes repeatedly until specified criteria are met.

The purpose of this chapter is to discuss some design issues on this Social Decision Support System (SDSS) Toolkit; the List Gathering Tool in particular. Based on the previous discussion of the requirements for a group decision support system, especially a List Gathering Tool, this chapter mainly presents the design of the List Gathering Tool.

5.2 SDSS Toolkit Architecture

The SDSS Toolkit is Web-based. Therefore, it will be able to be accessed over the Internet *any time, anywhere*, and can be embedded into other group support systems. This toolkit has several components. They are a Role Management Tool, a List Gathering Tool, a Scaling Tool, and a Voting Tool. Each component can either be used independently or be combined with other tools.

The ***Role Management Tool*** will handle user registration and password control, and can give a group manager the ability to assign different roles to different members. A set of predefined user roles (such as, administrator, member, observer, etc.) is available in the tool. The privileges of each role for the List Gathering Tool are discussed in detail in the next section.

The ***List Gathering Tool*** can help a group of users to collaboratively pull their ideas together, and provides a structure to organize those ideas into a list. It provides a structure that relates all the contributions made by the individuals in the group which produces a group view or perspective. Groups can build several related lists (e.g., a list of tasks to accomplish, a list of goals to achieve, etc.) to help themselves solve complex problems. In each list, group members can also vote on modifications (better wordings) to a specific item.

The ***Voting Tool*** can let groups vote/evaluate the list collected by group members. The list being voted on can be either collected by the List Gathering Tool, or created by a group manager directly.

The ***Scaling Tool*** can help groups to select scaling methods (such as, "yes/no", rank order, Likert scales, semantic differential, etc.) on the items on which they are going to vote.

The architecture of this SDSS Toolkit is shown in Figure 5.1.

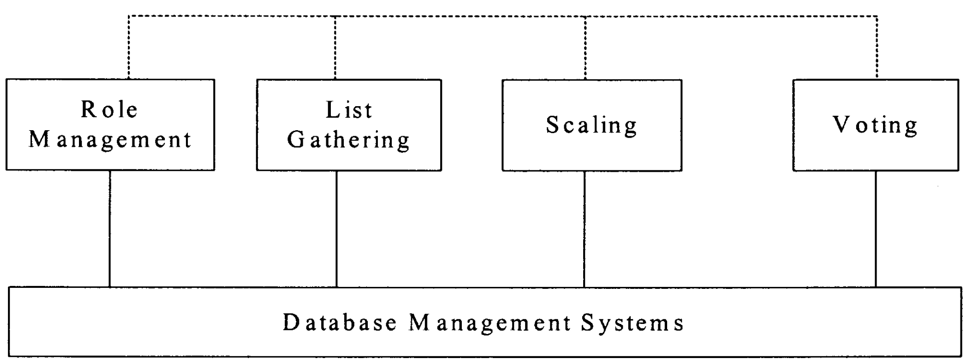

Figure 5.1 SDSS Toolkit architecture.

As stated in Adaptive Structuration Theory (AST), groups will not always use coordination structures designed with a deterministic view in ways intended by system designers. They will actively choose appropriate (or inappropriate) technology to their own needs. Some studies on group coordination corroborate the need to provide a less restrictive structure to give more flexibility (Anson et al., 1995; DeSanctis et al., 1989; Dickson et al., 1993; Dufner et al., 1994; Kim et al., 1998; McLeod, et al., 1992; Wheeler et al., 1993). All of the above studies observed the positive impact of the less restrictive coordination structure. The SDSS toolkit is flexible enough for groups to adjust their contributions and indicate relationships among them in a highly easy to do manner. Groups can use the List Gathering Tool to collect lists of items for later voting so that they can get as many ideas as possible. They can also use the List Gathering Tool after voting on a certain list, so that they can focus more on the disagreements they found in the previous voting session.

5.3 List Gathering Process Model

The process diagram in Figure 5.2 illustrates the communication process of the List Gathering Tool.

There can be multiple lists under one topic. Group members can be working on different lists at the same time. Each group member will decide on which list to work on at the beginning.

The process of list gathering begins when a new root item (defined later) is proposed by a group member. Other group members can then make comments on the root item, and they can suggest alternative wording (modification) for this item or combine several items into one. A comment can be classified as "pro" (support), "con" (oppose), or impartial "neutral". Once a new modification is proposed, all group members can vote on it to decide whether the original item should be replaced by the modification suggested. When a certain pre-determined threshold (e.g., more than 50% of the active group members vote "yes" to the modification) has been reached, or if the group manager or the author of the original item decides to do the replacement (depending on the system setting), the original root item will be replaced by the modification. Items that are rejected are stored in the list history and frozen for further discussion but remain visible to group members so they can see what has been rejected. When the group members feel that they have reached a point of apparent agreement on wording, or a certain timeline is met, which is set when the manager creates the list, the list will be frozen, and a voting session can be initiated, using the voting tool as needed so that group members can vote on all the items proposed.

As with the proposal to substitute better wording the original author can accept the suggested change anytime before the necessary vote is obtained. It is also possible for the monitor of the process to perform the same function. However, the objective is to encourage the group to operate without the need for human facilitation intervention.

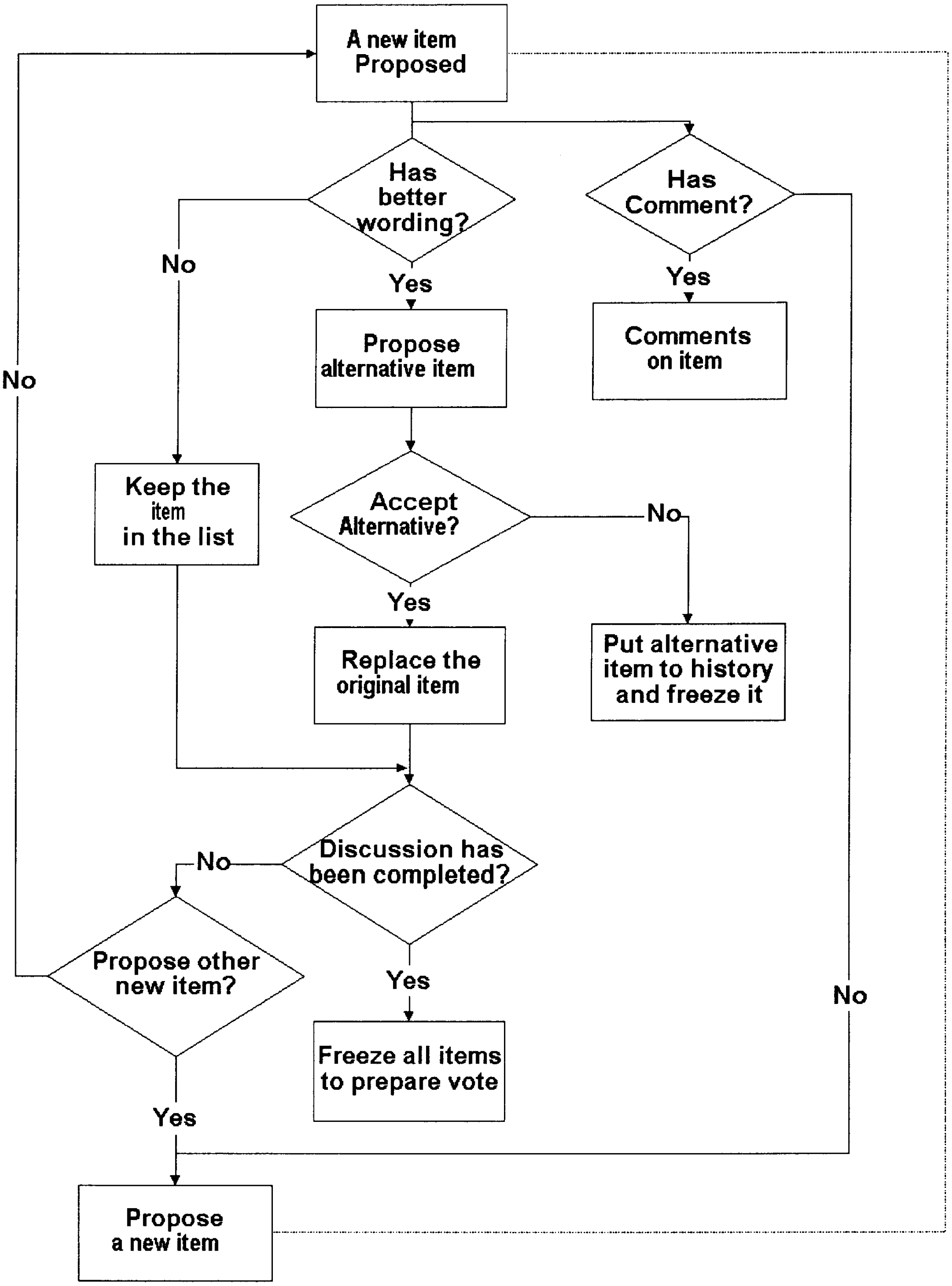

Figure 5.2 List Gathering process model.

5.4 List Gathering Tool Features

As discussed in previous chapters, during the group decision-making process, one needs to collect a list of ideas, options or considerations along with comments about their ideas. The List Gathering Tool is able to collect any list of possible items, such as goals, objectives, tasks, criteria, solutions, names, labels, plans, comments, arguments, etc. The list-gathering tool allows group members to work on *any available list at any time*. For example, a group may be discussing the selection of stocks. In a traditional synchronous meeting, they would have to work on a strict agenda, which might be discussing their objectives first, then discussing all the available alternatives, and finally finding the solution. In this case, all the group members are working on one list (objective, alternative, or solution) during the same time period. However, this will not be the case if they are using the web-based List Gathering Tool. They can work on any list (objective, alternative, or solution, etc) at any time. Any individual member can work at his/her own pace (Hiltz, 1990). Also, they can build relationships among these lists (items may be linked across lists), so that it will be easier for them to focus on the problem and find the best solution.

The objective of this system is to allow every individual to deal with whatever aspect (or whichever list) they want to work with at that time, but provide the group as a whole with a view of what is happening on a collective basis.

The main considerations of the list-gathering tool are to provide users:

- Easy access
- Flexible means to create and manipulate lists
- Status control

- Membership (role) control
- System awareness

Keeping the above principles in mind, this Web-based List Gathering Tool is designed to have the following features:

1. Group members can add an item to the list at any time.
2. Group members are able to have a draft space to see how their possible contribution looks before choosing to submit it to the group. Display of the lists may be hierarchical so that items go into a tree structure rather than a linear structure. The lists can also be formed in a network so that the relationship between lists, or the relationship among lists and items, will be easy to identify.
3. Lists can be gathered in different ways, such as providing linkages among data objects, referring to a message or a comment or other items that occurred in earlier communication, providing links to outside material (e.g., a URL of a useful material), or reusing a list collected from other approaches.
4. Semantic links can be created by group members. Since several lists might be involved in the problem solving process, there might be some kinds of relationships between items in different lists. For instance, in order to find out the criteria for selecting computer equipment for an organization, group members need to work on at least two lists of criteria: absolute criteria and relative criteria. After defining a specific criterion in the relative criteria list, group members might find a relation between this criterion and one criterion

or several criteria in the absolute criteria. In this case, a semantic link can be created by group members to define the relationship among those criteria.

5. Alternative wordings (modifications) of a root item and/or synergy among some items can be proposed by group members. The group manager will be able to determine whether to ask other group members to vote or let the author of the list/item to decide whether to accept or reject the proposal. There will be a pre-determined threshold (e.g., more than 50% of the group members voted "yes") to decide whether to accept the change.
6. A status is associated with items on the list. Possible statuses are:
    - **Open**: Anyone can contribute to the list.
    - **Suspended/Frozen**: Viewable but no changes to the items can be made by normal group members. Regular members can post their pro, neutral or con comments to the items. Only the monitor can edit the items.
    - **Viewable**: The condition under which group members are allowed to view a certain list. For example, one cannot read what has been contributed until he/she has contributed.
    - **Closed**: The list will not be used further in the group process.
    - **Interrupted**: If some changes have been made to the list after the list is submitted to a voting procedure, it may invalidate all prior votes.
    - **Required**: No one can skip this activity.
    - **Sequenced**: One activity cannot be started until all indicated prior activity has been done.

- **Vote Granted/Initiated**: A voting session has been granted. Group members can view the contents of the list, vote on the root items. However, only pro, neutral, or con comments can be posted to the corresponding item. No other change can be made to the list itself. This status is available only when the voting tool is used along with the List Gathering Tool.

7. The status of the list can be tracked – whether the list has been open or in other states, who last modified the list and when, etc.
8. Based on their preferences, members will get notifications about new events. For example, a creator or a manager may receive notifications (by email, or posting to a list) when other group members add new items into the list.
9. Turoff (1991, p. 95) suggested, "Human roles, and the computer support of human roles, are key factors in the success of group activities." Dennis, et al. (1997, p. 169) also argued "to be flexible yet restrictive, there had to be several different categories of users, each with different access rights." There are some normal roles that are associated with list gathering:
    - **Owner/Creator**: This person has the power of modifying and closing or deleting the list. The owner can also specify the maximum levels of the list when he/she creates the list (depth of a tree structure).
    - **Member**: Regular member role which may respond, or view a list.
    - **Manager**: This role has the same power as OWNER, but cannot delete that list if he is not also the OWNER. MANAGER can also assign roles to group members, and reorganize all items in the list.

- **Observer**: A person who can only view the list but not contribute to it.

10. The history of all the activities under each list will be made available to group members. Group members should be able to see all the modifications made on each item so that they can determine whether what they want to contribute has already been expressed in other form.

5.5 List Gathering Tool Implementation

The List Gathering Tool is implemented using ColdFusion 5.0. A web user can access it via http://westwing.njit.edu/SDSS/SDSSLogin.cfm (Figure 5.3). The user will need to have an account on the system before he/she can enter the system.

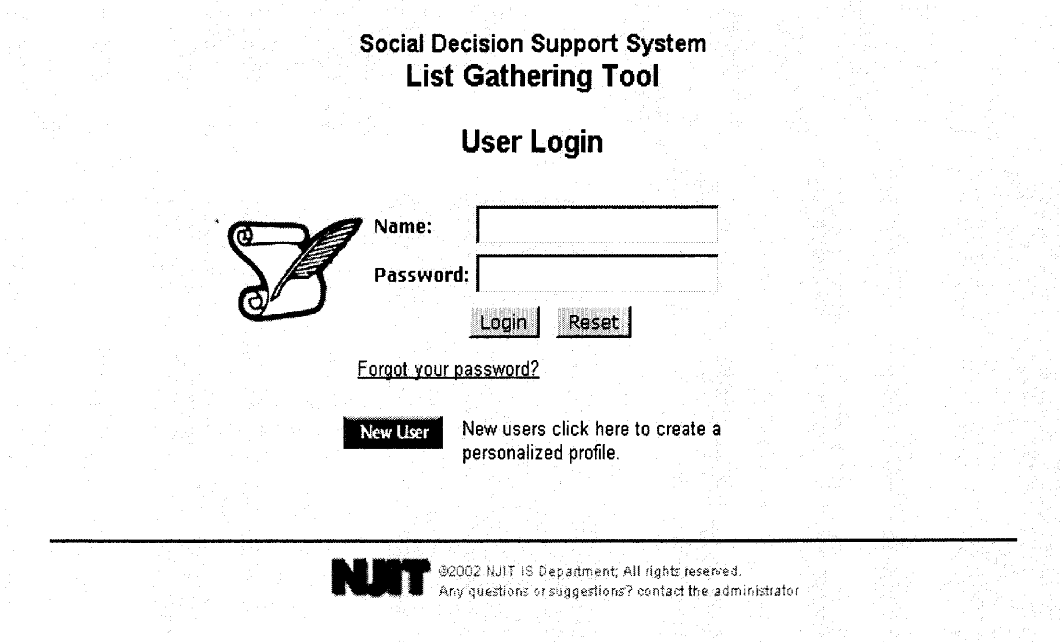

Figure 5.3 The login page of the List Gathering Tool.

The following are the definitions for some terms used in this List Gathering Tool:

- **Topics**

  Topics are the subjects of a discourse. For example, users can have "Trip" as their discussion subject.

- **Lists**

  Lists are the areas in which users can organize their discussion topics. They can have multiple lists within one topic. For example, they can have "Shopping List", "things to do", "things to wear" lists under their "Trip" topic.

- **Root Items**

  Root Items are listed within each List. A root item is a specific idea in one list. For example, in the List called, "Shopping List", there can be several root items: "noodle", "Vegetable", etc.

- **Modifications (Mods)**

  Modifications, also called "Mods", are used when users want to suggest better wording for an existing root item which has been posted by another group member. For example, "Veg*e*table" is a modification of "Veg*i*table". The title of the modification should be meaningful so that everyone can understand what the modification is talking about.

- **Comments**

  Comments are postings which contain group members' opinion on a specific root item. Group members can post their rationale on whether they are supporting or opposing the idea. Comments can be supportive ("Pro"), objective (" Con"), or just a general opinion ("Neutral").

- **List Status**

  Each list can have one of four types of status: "Open", "Frozen", "Closed", or "Granted for Vote".

  If a list status is "Open", topic members can add/edit/delete a Root Item/Modification/Comment in the list.

  If a list status is "Frozen", topic members cannot add/edit/delete any Root Item/Modification in the list. Only the topic manager or the administrator can edit the root items in the list. General members of the group can add their pro/neutral/con comments to the root items.

  If a list status is "Closed", topic members cannot do any other operation in the list (including add/edit/delete a Root Item/Modification /Comment to the list, or vote on the root items of the list) except read all the postings or check the voting result (if it is used with a voting tool).

  If a list status is "Granted for Vote", one cannot change the status of the list unless the voting session is stopped. Topic members can only vote on the root items of the list, or check the voting result, but they cannot do any other operations (including add/edit/delete a Root Item/Modification /Comment in the list).

  Only the system administrator or the topic manager can change the list status.

As discussed above, the List Gathering Tool is divided into topics and lists, which contain root items. The user will see a list of topics which is available to him/her when he logs in to the system. Topics can be open to the public so that everyone who has an account on this system can have access, or private so that only a certain group of people can access. Each group can have their own topics. Each topic is made up of one or more lists. All people who are the members of the topic can post or read messages, including Root Items, Comments, and Modifications. Each topic can have a number of observers who can only read all the postings, but cannot contribute their own ideas. Each list is composed of Root Items, Comments and Modifications, which are grouped by the Root Items within each list.

Figure 5.4 presents the interface of the List Gathering Tool. The SDSS Toolkit's main screen is divided into three areas or frames:

- **Navigation Menu**

  The top frame contains menus with options. It presents all the main features of this tool.

- **Summary of the Current List**

  The left frame presents a summary of the current list you are working on in a table. The current topic, current list, and all the root items and their related comments and modifications are listed under the summary table. Users can select the number of root items, comments, and modifications to be displayed by clicking the link in the summary table. For instance, when a user clicks the number corresponding to the number of new comments, she/he will see only the root items with new comments listed under the summary table.

- **Main working area**

  The right frame is the main working area. It shows a welcome message when a user logs in the system. This area will be the place where users can input their ideas, read all postings, etc.

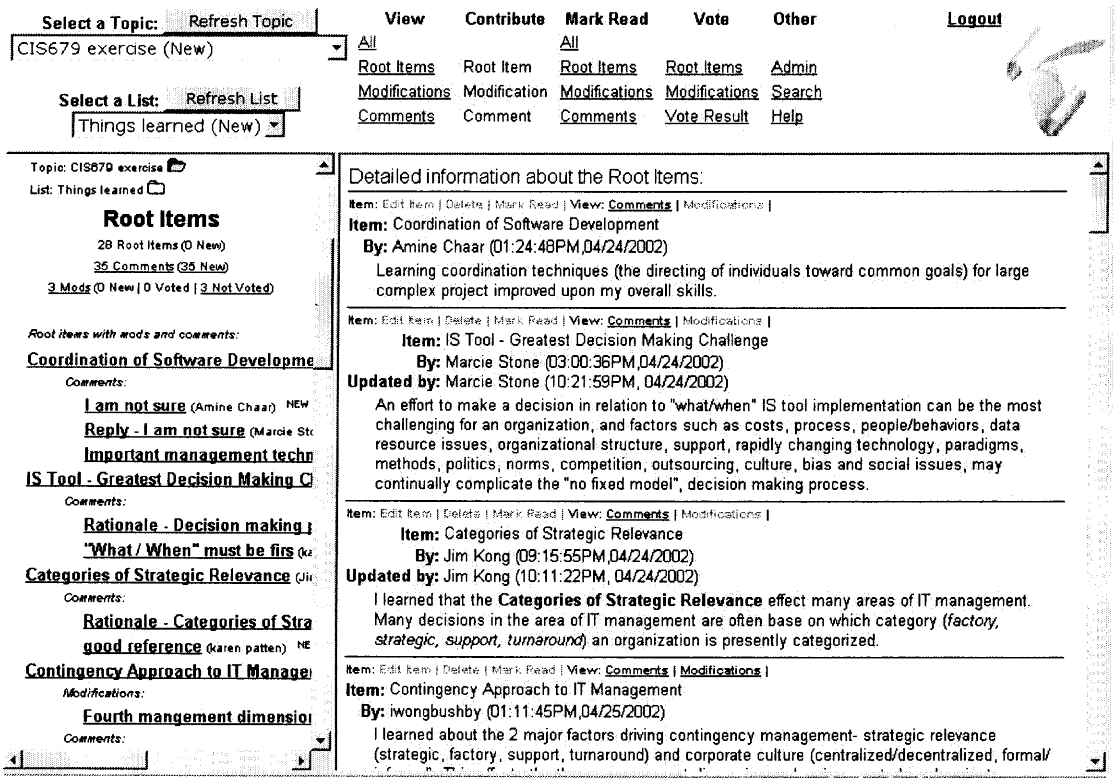

Figure 5.4 List Gathering Tool implementation.

When displaying the root items, comments and modifications, the system not only gives prompts for the type of posting, but color codes all the postings as well. For example, root items are presented on a light blue background; comments are presented on a light gray background, while modifications are presented on a light red background to attract the user's attention. The meaning of each color code is explained in detail in the training material.

Whenever a modification (better wording) is suggested, a voting process on the modification will be triggered automatically. Group members can vote “yes”, “no” or “no judgment” on the modification. When a pre-defined threshold is met or if the manager/creator of the root item decides to replace the wording of the root item, the root item will be replaced by the modification, and the original root item will be stored in the history. This feature is designed so that the number of duplicate root items can be reduced. Therefore, information overload may be reduced during the group process.

To view the information of a list in detail, one can either begin with the first item in the list, or select the starting point of the information. In both cases, the user will have the following different ways (view mode) to choose from:

- **View All:** View root items with their modifications and comments
- **View Root Items:** View only the information of the root items
- **View Modifications:** View only the root items with their modifications (Only root items that have modification(s) will be displayed)
- **View Comments:** View only the root items with their comments (Only root items that have comment(s) will be displayed)

When a user selects a certain root item in the list, the user will see the items she/he selected and all the root items below it (with or without comments and modifications depending on which view mode he/she is in) in the list. The default is to view all the information about the root items with their modifications and comments (i.e. "View All").

A detailed step-by-step tutorial on the features of this tool and how to use them is available on the web at http://westwing.njit.edu/training/SDSS/definition.htm

5.6 Summary

This chapter discussed the design of the SDSS Toolkit, List Gathering Tool in particular. The List Gathering Tool enables groups to easily retrieve sets of related, well-organized ideas at any time during the group decision-making process without having to comb through the huge amount of information in a conference system.

Although this system was designed to help groups to organize ideas, there is still a lot to be done to improve the performance of the system. The effort of gathering users' feedback from field trials and a controlled experiment and their results will be discussed in the following chapters.

CHAPTER 6

USER TESTING AND EXPERIMENTAL DESIGN

6.1 Introduction

As stated in the previous literature review, although many decision support tools have already been implemented or used, information is buried in large amount of "messages" in most tools. People have to comb through all the messages posted in the tool to find useful information. There is still limited success in dealing with discussion by large groups concerning complex problem. The basic problem of information overload (Chen et al., 1994; Chin et al., 1992; Dennis, 1996; Eden et al., 1992; Gallupe et al., 1991; Nagasundaram et al., 1993; Nunamaker et al., 1991) encourages various group process losses such as "rush to decisions" and limiting consideration of many alternatives.

In this research, the researchers are concerned with using appropriate decision tools for facilitating a full understanding by the group of individual preferences among its members. Moreover, they hope these tools can aid in determining the degree of understanding and agreement at any time in the group process.

As a result of being able to accomplish this, the researchers propose that groups will obtain more accurate group judgments than without the support of a social decision support toolkit; that is, a group will be more likely to develop a group view of complex problems that is more consistent with the views of the group members at the end of the process. Furthermore, consensus of the group will be either enhanced, or the individual members in the group will better understand the lack of consensus, so that the overall accuracy of the group judgment, and the perceived satisfaction of the group, will be improved.

In an effort to reach these goals, the author and her colleague, Zheng Li, developed a new Social Decision Support System (SDSS) toolkit, which is composed of two main parts: a List Gathering Tool and a Dynamic Voting Tool. The List Gathering Tool (Chapter 5) provides fundamental structures under other components in the toolkit to help groups effectively organize their ideas into different lists, such as lists of criteria, lists of alternatives, or lists of solutions, etc. The Dynamic Voting Tool is used to help group members interactively obtain individual preferences on the previously formed lists, and help form group preferences. For instance, if users are going to develop an equipment-purchasing plan using this toolkit, the List-gathering Tool may help one effectively identify all the criteria in a structured way. Then each member in the group may choose to vote on the alternatives using appropriate voting methods. Based on the individual voting result, the group can form a single group opinion or try to revise their list and vote again. At the end, groups will be able to form a group opinion on what are the final criteria the group chooses. The author hopes this toolkit will be able to help groups organize their ideas and find the solutions in solving the problem at any time, any place. Moreover, it is expected that as the result of using this tool, groups will be able to develop a group view on complex problems more easily, in a more organized way, so that group judgment on the problem will be enhanced, and the perceived satisfaction of the group members will be improved.

In order to determine whether this toolkit and its special features would actually enhance satisfaction, decision quality, etc., the researchers tested the difference between the presence and absence of this tool and its features in this research. The evaluation processes, which include protocol analysis, a laboratory experiment, and several field trials (Chapter 8), have been conducted to test the effects of this toolkit.

6.2 Protocol Analysis

6.2.1 Theoretical Background: What is Protocol Analysis?

Protocol Analysis also is called the "Thinking Out Loud" or "verbal protocol" method. This method was first utilized in the area of psychology. Newell and Simon (1973) were among the researchers who first developed "verbal protocols". They argued that the systematic collection of this type of observation could be used to test information processing models of human reasoning. Turoff and Hiltz (1997) also pointed out that the verbalizations made by the human problem solver are at least a meaningful subset of those mental processes that determine his or her behavior. This method has been extensively used in the development and design of computer systems. It has become one of the most commonly used usability testing methods.

The method described by Erisson and Simon (1984) has been regarded as guidance for doing protocol analysis. They recommend using minimal interaction during the study – just use "keep talking" to remind subjects to think aloud. A lot of researchers (Boren and Ramey, 2000; Dumas and Redish, 1994; Nielsen, 1993; Rubin, 1994; Turoff and Hiltz, 1997) have also given some specific advice on conducting protocol analysis.

In this method, the researcher records the step-by-step procedures of a user "thinking out loud" while trying to use a computer system (Turoff and Hiltz, 1997). In protocol analysis, users are asked to think aloud as they work, and are prompted with "What are you thinking?" throughout the sessions as necessary to keep this self-disclosing monolog going (Carroll and Mazur, 1986). It is a qualitative, direct observation method for accessing usability of software. By using this method, researchers can understand a user's cognitive model of the system, so that they can pinpoint differences between the system model and the user model. Researchers can better understand the cause of errors, mistakes, and misinterpretation. This method can help researchers pinpoint important problems, find out why problems occur and catch them when they occur, detect "minor" problems which affect user acceptance of the system. This method can be used at the early stage of system development.

However, there are some potential problems with this method. Firstly, thinking aloud is not a normal behavior and may well affect the learning process itself, i.e., the verbalization may change the way people think (Santos, 1994). For example, learners who are thinking aloud might be more (or less) careful or methodical than learners in real situations. Secondly, making comments takes time, which must affect measures of time to complete tasks (Carroll et al. 1985). Thirdly, people cannot verbalize all of their mental processes (Nisbett and Wilson, 1977). Fourthly, this method is very time consuming and labor-intensive, which means it cannot be done with large numbers of subjects.

Boren and Ramey (2000) summarized the following rules when conducting protocol analysis:

Collect and analyze only "hard" verbal data. The only data considered must be what the participant attends to and in what order.

Give detailed initial instructions for thinking aloud. Researchers should distinguish between explanation and thinking aloud. It should be made clear that researchers will only give subjects reminders if they fall silent. Subjects should practice thinking aloud before the real task begins.

Remind participants to think aloud. There should be a predetermined time period of silence (15 to 60 seconds) for a reminder to be necessary. The reminder should be as short and non-directive as possible.

Otherwise, do not intervene. The only interaction between the researchers and subjects during the thinking aloud session is when the reminder is needed. The researchers should keep themselves "small" in relationship to the participant. They should not expect the user to tell them how to fix the problems or answer other design questions.

Several techniques that can encourage thinking out loud have also been suggested by researchers (Turoff and Hiltz, 1997; Ramey, et al. 2000):

Prompting. Explore user thinking in a neutral way. Do not be too quick to assume that the user is lost or having a problem. Some of the questions the researchers may ask are "what is your goal?" "What are you thinking?" "Tell me about your thinking here".

Echoing. Repeat their own word or phrase to set up a social dialog and reinforce social conversation expectations so that the subject can talk more about their thinking. Do not offer interpretations. Give signal ("Mmm hmm…") to show that you are listening.

Summarizing at key junctions. When you have learned something new that is key to understanding, summarize the event very briefly. Keep the recorder on and keep taking notes after the session is finished.

During the session, the screen can be captured using screen capture software, and user's gestures can be captured using videotape. Audiotapes can be used to record the talking from the subjects. At the end of the session, researchers can have a prepared semi-structured interview with the subjects. From the interview, the overall impression the users have toward the system can be obtained.

After each session, the videotapes and/or audiotapes need to be transcribed first, and then analyzed. When analyzing the data, one should pay more attention to where users have difficulty or complain, list each episode and relate it to an aspect of the system, group them by types, rank severity of each problem, and try to understand the reasons for problems.

In order to generalize the results of protocol analysis, different user groups, such as novice groups and expert groups, have to be studied. Usually, three to four subjects from each user group are needed to represent the user population (Turoff and Hiltz, 1997).

By using this method, researchers can understand users' cognitive models of the system, so that they can pinpoint differences between the system model and users' models. Researchers can better understand the cause of errors, mistakes, and misinterpretation, and take steps to improve the system. Therefore, the author used the protocol analysis as the first step of the evaluation of this List Gathering Tool to pilot test user interface for redesigning the interface before the user experiment was conducted.

6.2.2 Protocol Analysis Procedures

In order to carry out a good protocol analysis which represents different user groups, the author selected subjects from IS graduate students. Since there are a lot of students who have extensive experience in decision-making (e.g., students who worked as a manager for several years), they were considered as experts in decision-making. The graduate students who have already taken some decision-making courses but do not have real experience represented a "novice" user group.

The procedures for the protocol analysis used for this study were:

1. Designed a set of tasks for the study. In this study, the tasks include sign up for the list gathering website, contribute an item to a list, suggest a better wording for an existing item, make a comment on an existing item, and vote on a suggested wording.
2. Prepared a consent form and an interview guide.
3. Recruited subjects. Five NJIT IS graduate students, who will be the users of this toolkit, were selected as the subjects for this study during the summer of 2002. All of them were considered as interface experts. One of them was also considered as the expert in group decision making.
4. Run first set of protocol analysis (one novice user, one expert user) to test the research instruments.
5. Modify research instruments.
6. Run main study (three subjects).
7. Analyze all the recorded material.

For each protocol analysis, the following procedures were followed:

Gave a brief introduction of "thinking out loud" to subjects. In order to let subjects know how to perform the task in this process, the author gave them a simple demonstration on how to do the “thinking out loud”. (They actually knew how to do this exercise since they had done this kind of exercise as part of their course work before.)

Asked subjects to sign the consent form and fill out the pre-questionnaire.

Gave subjects the task list, which includes the tasks to sign up for the list gathering website, contribute an item to a list, suggest a better wording for an existing item, make a comment on an existing item, and vote on a suggested wording, which the author posted as a seed.

During the procedure of subjects doing the task, the data was recorded using audiotapes to record the “protocol” and a notepad to record the screen events. When they forgot "thinking out loud", the author reminded them to talk. Detailed instruments for conducting this study are presented in the next section.

After doing the tasks, follow-up semi-structured interviews were conducted.

Subjects were debriefed at the end.

6.2.3 Research Instruments

The research instruments used for this study include “Protocol Analysis Research Guidelines”, “Instructions for Evaluators”, “Consent Form”, “Background Questionnaire”, “Evaluation Task Form” and “Interview Guide”. They are available in Appendix A.

6.2.4 Protocol Analysis Results

From protocol analysis, the following problems were identified:

- Some typos on the interface were found. For example, "Neutral" was typed as "Netural".
- The presentation of the root items, comments, and modifications were suggested to be color-coded. And the sequence of the information in root items, comments, and modifications were also suggested.
- The summary of the currently selected list was suggested to be organized into a table.
- Instead of using two large boxes to display the available topics and lists, pull down menus were suggested to save the screen space for other functionalities.
- Instead of forcing users click "Select" button to change the working topic or list, the screen was suggested to be automatically refreshed whenever a new topic/list is selected.

The results of protocol analysis were helpful to find some potential problems, which were not noticed by the designers. This method is used to find out problems in both the system functionality and the system interface. Then, the author improved the system based on the above feedback.

After doing the protocol analysis and improving the system functionality and the system interface, the researchers conducted a controlled laboratory experiment and several field trials to test the effects of this List Gathering Tool (and the combined SDSS Toolkit). In the following sections, the design of the experiment will be discussed.

6.3 Conceptual Model

The conceptual diagram of this experimental study is as follows:

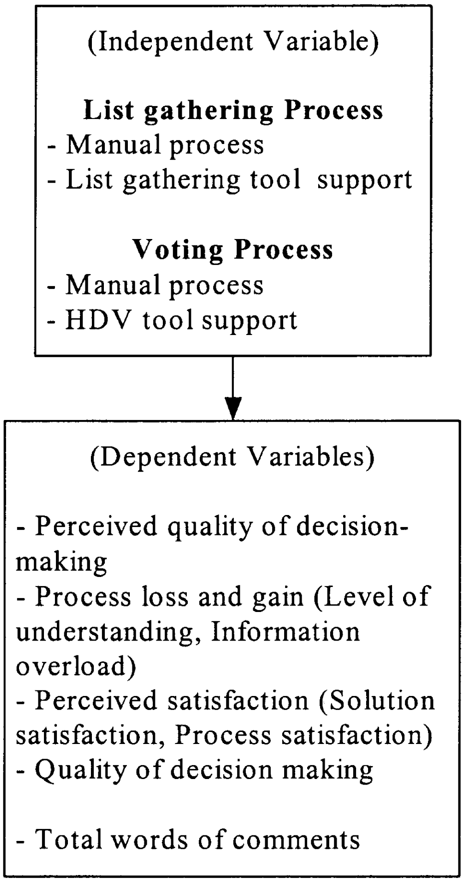

Figure 6.1 Conceptual model.

6.4 Experimental Design

6.4.1 Independent Variables

The experimental design is a two-by-two factorial shown below. The factors are: list-gathering process (with tool support / manual) and voting process (with HDV tool support / manual).

Table 6.1 2 x 2 Factorial Research Design

		List Gathering Process	
		With List Gathering Tool Support	Manual
Voting Process	With HDV Tool Support	**LV**: With List Gathering and HDV tool support	**NV:** Manual list gathering, with HDV tool support
	Manual	**LN:** List Gathering support, Manual voting	**NN:** Manual list gathering, Manual voting

As a web-based toolkit, users are able to access it at any time, anywhere via the Internet. Therefore, the communication mode of this experiment was asynchronous only. A face-to-face meeting is not necessary through out the whole experimental procedure. For the baseline condition (NN, manual list gathering, manual voting), a web-based conferencing system – "WebBoard" will be used to finish the task, without any structured toolkit support.

6.4.2 Dependent Variables

The dependent variables including both subjective measures and objective measures are:

Subjective measures:

- Perceived quality of decision-making
- Process loss and gain (Level of understanding, Information overload)
- Perceived satisfaction (Solution satisfaction, Process satisfaction)

Objective measures:

- Quality of decision-making
- Total words of comments by the designated leader and other members

A group of expert judges was used to judge the quality of decision-making based on the groups' reports. A computer program was used to count the length of comments contributed by each group member. Other dependent variables were measured using questionnaires.

6.4.3 Task

A computer equipment-purchasing task was developed to be used in this experiment (See the Appendix B.3).

NJIT distributes PC to freshman each year. A special task force has been working on a similar task which helps the university make decision on choosing computer vendors. The experimental task was developed with the help from a person in this task force to present a real scenario for student subjects. The author believes that this will give subjects a feeling of doing a real task that relates to both their education and work experience. Therefore, subjects will be motivated to complete the task. Moreover, the results from this experiment may benefit the university on its PC distribution program; and people in the task force will be the best candidates as judges to evaluate the quality of the results.

According to McGrath (1991), this experimental task is a complex task (type IV). The task requires group members to come up with two lists of criteria (absolute criteria and relative criteria), present reasons to support their selections, and rank order the relative criteria according to their importance. With different experiences, subjects will be exposed to diverse views of the task. To finish this task, subjects need to discuss the alternatives proposed by group members, resolve their disagreement, and deliver a group report with their optimal solution at the end. Therefore, the researchers think that with the complexity of this task and its ability to bring various group views, it is a good fit to test the effects of the List Gathering Tool; with the need to discover the disagreement among group members and finally getting a rank-ordered list, this task is also suitable for the test of the effects of the Voting Tool.

6.4.4 Subjects

The subjects of this research were recruited from the student body of the New Jersey Institute of Technology (both undergraduate and graduate students). Total of 253 students participated in the formal experiment, of which 187 students successfully completed the experiment. All of them were taking (or have already taken) a course related to decision-making and requirement analysis. About 15 to 20 percent of course credits were given for participating in the research. Students were told that their participation was voluntary and confidential. Students were also told that they could choose not to participate in the research and alternative assignments were made available for them, with no negative consequences for them if they chose not to participate in the study.

In order to provide a sufficient level of "power" to the statistical analysis, at least ten groups per cell were conducted with five to seven subjects per group. As the result of dropouts, total of 33 groups were valid (eight to nine groups per condition with five to seven subjects).

To mix all groups by gender, age and previous experience, experimental subjects were assigned as randomly as possible into different treatment groups given time and scheduling constraints. Due to the shrinkage of the student body in NJIT, researchers had to introduce undergraduate students from two IS courses (CIS 350 Computers and Society, and CIS 465 Advanced Information Systems) into the study to make sure they have enough subjects. Since the researchers were concerned about the possible differences between undergraduates and graduates, they grouped undergraduates and graduates separately while keep the randomization within each level of degree program groups. In order to keep the background of the subjects in each condition similar, at least two undergraduate groups were used in each condition. The levels of degree program (graduate vs. under graduate) were considered as another control variable. Subsidiary results comparing graduate and under graduate groups were reported at the data analysis chapter (Chapter 7).

All subjects were given one standard online training session (or two sessions for tool-supported groups) and experimental task and completed the same set of questionnaires. The responses on the questionnaires were analyzed after the experiment.

The nature of the task and responsibilities were explained to students prior to the decision on being a subject. Students who chose to participate were required to complete the consent form and background questionnaire online. Questions raised by students were answered. Students were told that they would be informed by email about accessing the training materials.

6.5 Hypotheses

Previous empirical research reported mixed results in terms of perceived quality of decision-making, satisfaction, process losses and gains when comparing the presence and non-presence of certain GDSS support. The toolkit is developed for the purpose of increasing the understanding of the information provided and hidden in the problem, finding the relationships among information elements, helping groups discover the disagreement and then focusing on the disagreement by providing a fundamental structure to groups. Therefore, the researchers expect to see an increase in the perceived quality of decision-making, process gains, satisfaction, etc.

6.5.1 Perceived Quality of Decision-making

Mixed results have been reported on comparing groups with and without GDSS support (Dennis et al, 1990; Gallupe 1985; Gallupe et al., 1988, Valacich, et al., 1994; etc.). By providing a structure to help group members get useful information easily instead of combing through all the comments, the tool should be able to make group members feel that it is easier to work on the task and focus on the disagreement. Therefore, it should be able to enhance the group members' understanding of the information and have it fully analyzed. By using the tool, the improvement in the perceived quality of decision-making is expected.

H1. Groups supported by tools, compared to groups not supported by tools (manual groups), will have higher perceived quality of decision-making.

H1a. Groups supported by the List Gathering Tool, compared to groups not supported by the List Gathering Tool, will have higher perceived quality of decision-making.

H1b. Groups supported by both the List Gathering and the Voting tools (the SDSS Toolkit) will have disproportionately higher perceived quality of decision-making.

6.5.2 Process Gain and Loss

Research on process losses and gains also showed mixed results. Most experiments have reported that the presence of decision support tools can help groups to make better decisions than groups without the decision support tools. Malone et al. (1987) studied semi-structured messages in computer-supported communication. They have found that the semi-structured messages are "surprisingly useful" for computer-supported coordination. Dowling et al. (2000) also reported their finding that semi-structured information to filter the referential link can make it easy for receivers to judge. With features like user notification, mark read, color coded postings, and explicit link(s) in items, users should be able to focus more on their task. Therefore, the researchers hope using this tool can improve their level of understanding of the task (process gain) and at the same time reduce the information overload (process loss) to some extent.

H2. Groups with tool support, compared to groups without tool support(manual groups), will have a higher level of understanding of the task.

H2a. Groups with the List Gathering Tool support, compared to groups without the List Gathering Tool support, will have a higher level of understanding of the task.

H2b. Groups with both the List Gathering and the Voting tool support (the SDSS Toolkit) will have disproportionately higher level of understanding of the task.

H3. Groups with the tool support, compared to groups without the tool support (manual groups), will have lower levels of information overload.

H3a. Groups with the List Gathering Tool support, compared to groups without the List Gathering Tool support, will have lower levels of information overload.

H3b. Groups with both the List Gathering and the Voting tool support (the SDSS Toolkit) will have disproportionately lower level of information overload.

6.5.3 Perceived Satisfaction

The research on the perceived satisfaction also has mixed results. Since the toolkit is developed for giving groups better understanding and analyzing the information in a complex problem, researchers hope it will increase the satisfaction in terms of solution and process support.

H4. Groups with tool support, compared to groups without tool support (manual groups), will be more satisfied with their solutions.

H4a. Groups with the List Gathering Tool support, compared to groups without the List Gathering Tool support, will be more satisfied with their solutions.

H4b. Groups with both the List Gathering and the Voting tool support (the SDSS Toolkit) will be disproportionately more satisfied with their solutions.

H5. Groups with tool support, compared to groups without tool support (manual groups), will report higher level of satisfaction with their group process.

H5a. Groups with the List Gathering Tool support, compared to groups without the List Gathering Tool support, will report higher level of satisfaction with their group process.

H5b. Groups with both the List Gathering Tool and the voting tool support (the SDSS Toolkit) will report disproportionately higher level of satisfaction with their group process.

6.5.4 Quality of Decision-making

Giving groups a clearer idea about all the items in the information and their relationships should help individuals and groups to better recognize potential solutions of the problem. Therefore, an improvement in terms of quality of decision-making is expected.

H6. Groups with tool support, compared to groups without tool support (manual groups), will have higher quality of decision-making.

H6a. Groups with the List Gathering Tool support, compared to groups without the List Gathering Tool support, will have higher quality of decision-making.

H6b. Groups with both the List Gathering and the Voting tool support (the SDSS Toolkit) will have disproportionately higher quality of decision-making.

6.5.5 Other Research Questions

Will the use of this SDSS toolkit affect the length of comments? Will it result in shorter comments while using the List Gathering Tool? Instead of being buried in all the messages posted by group members in a conferencing system, the ideas will be organized into a meaningful list by using the List Gathering Tool. This will help groups find related ideas easier. Therefore, group members may not need to make lengthy comments on each idea and try to dig it out later.

The following questions are also asked, "Will the presence of the SDSS toolkit affect the group participation and group leadership?" "Will the leader make more or less contribution to the group by using the tool?" Equal participation by group members is anticipated, not only because of the implementation of an anonymity/penname mechanism, but also because of the structure the tool provides.

6.6 Procedures

Two pilot studies were conducted before the formal experiment to test the fitness of the task, instruments, and the performance of the SDSS toolkit.

6.6.1 Pilot Study for Baseline Groups

A pilot study on the baseline (no List Gathering Tool support, no Voting Tool support) condition was conducted during the summer of 2001. The main purpose of this pilot study was to test whether the description of the task is clear and understandable, whether the questionnaires are good to use, and whether the experimental procedure is easy to follow.

Eleven students from an IS course at graduate level volunteered to participate in the experiment. They were given course credits. Other students who didn't participate in the study were given an alternative assignment for the course credits.

The experiment was conducted using the WebBoard conferencing system – manual condition (no List Gathering Tool support, no Voting Tool support). The students were randomly assigned into two groups with five in one group and six in another. They finished the consent form and the background questionnaire first. After completing an online training session on how to use the WebBoard, subjects sent their initial individual response to the investigator(s). At the end, each group completed the experimental task by delivering a group report. After all the group reports were collected, a post questionnaire was given to each participant to attain their feedback. All activities were finished online. No face-to-face meeting was arranged.

Based on the responses collected from those subjects, the following improvements on the instructions for the task and the experimental procedures have been made:

- A template for the final group report was designed to make the requirement for the experimental task clearer.
- The whole time period for the experimental task was extended to ten days.
- A designated coordinator for each group was added.

6.6.2 Pilot Study for Tool Supported Groups

After the implementation of the toolkit, several rounds of protocol analysis, and system improvement, a second pilot study for other conditions of the experiment (tool support conditions, i.e., condition LV, LN, NV) was conducted during the summer of 2002.

The purpose of this pilot study was to get more feedback on the tool design, the procedure for tool support conditions, and the online tutorials.

A total of 33 students from two graduate IS courses volunteered to serve as the subjects for this pilot study. They were given course credit for participation. Other students who didn't participate in the study were given an alternative assignment.

The experiment was conducted using either one of the components in the SDSS toolkit (the List Gathering Tool or the Voting Tool) or the SDSS toolkit (both the List Gathering Tool and the Voting Tool). There were two groups for each of the three conditions. The students were randomly assigned into six groups with five in three groups and six in the others. First, they finished the consent form and background questionnaire online. After finishing an online training session on how to use the WebBoard and the corresponding system (depended on the condition they were in), subjects submitted their initial individual response to the investigator(s), and then carried out the experimental task in a group setting. After they submitted their group reports, an online post questionnaire was distributed to each participant to collect individual feedback. All activities were finished online. No face-to-face meeting was allowed. For groups with voting tool or SDSS toolkit support, the group coordinators were given the privilege to grant/stop a voting session.

This pilot study showed that it was a burden for the group coordinators to initiate/stop a voting session since most of them didn't really know how to do it. The researchers decided to let the groups make the decision on when to grant (initiate) and stop a voting session. Then, a voting session will be initiated or stopped for them at their required time in the real experiment. The following changes were also made to the instructions and the experimental procedure based on the feedback obtained from this pilot study:

- Added some definitions, such as Root Item, List, Topic, Grand/Stop Vote, etc., into the training materials.
- Separated training session into two sessions for tool supported groups, one two-day (48 hours) session for WebBoard training (same as manual baseline groups), and another two-day session for tool (List Gathering Tool, Voting Tool, or the combined SDSS Toolkit) training.
- A third list was added for List Gathering Tool only (LN) and SDSS Toolkit (LV) groups to allow group coordinators post group meta-discussion (such as, group schedule).

6.6.3 Formal Experimental Procedure

After the system development and the pilot studies, a formal experiment was conducted during spring 2002 and fall 2002. Since the system was still under development in spring 2002, the experiment was conducted with baseline (NN) groups only. 42 students (seven groups of six) from a IS graduate course participated in the experiment. After system coding and testing, formal experiment in all the conditions was conducted following the procedure below:

6.6.3.1 Subscribe Subjects. The researchers contacted the instructors, who taught management courses (such as Management of Communication and Managing IT for Competitive Advantage) or IS related courses (such as Computers and Society, Advanced Information Systems, Evaluation of Information Systems, and Principles of Information Systems, etc.), before they planned the syllabus for the course, seeking their cooperation, and gave details of the experiment schedule to the instructors to help them develop the course syllabus, alternative assignment, and grading policy. After getting agreement from the instructors, welcome messages and an experimental overview letter were sent (by posting in the class conference, or sending email) to the class introducing the nature of the experiment, providing the URL for accessing the consent form and background questionnaire, and asking for participation.

6.6.3.2 Obtain Subject Consent Form and Background Questionnaire. A consent form (see Appendix B.4) and a background questionnaire (see Appendix B.5) have been approved by the Human Subject Review Board. The author and her colleague, Zheng Li, have put all the experiment related materials, including all the questionnaires, consent form, and some administrative forms online as a questionnaire management system. The URLs for accessing those forms were distributed to the students via the experiment overview letter. The students were asked to fill out the questionnaires online to officially be counted as subjects in the experiment.

The online questionnaire system has a database to store the subject list and their feedback. After a subject submits the "consent form" and the "background questionnaire", the subject's basic information, such as name, email address, etc., is stored in a password-protected database which is separated from the experimental system. Meanwhile, the system automatically generates a unique code for each subject. Subjects then use their own name and email address to submit other questionnaires at the end of the experiment. The system automatically sends acknowledgment to subjects as they submit their feedback. Such a system reduces the time period for waiting the responses from the subjects, and it also saves great efforts to maintain research data. With this system, the researchers were able to check subjects' feedback, sort records very easily. Moreover, this system can be generalized to fit other study.

6.6.3.3 Assign Groups and Distribute Training Materials. After all subjects' "consent form" and "background questionnaire" were collected, subjects were randomly assigned into conditions/groups based on the response on "background questionnaire". All subjects got an email message with the URL for their training materials. During the training session, a full orientation to the system (WebBoard/ List Gathering Tool and/or Voting Tool) was given -- from getting a new account to logging off the system. For baseline groups, only training on the WebBoard system was given. For tool support groups, in addition to the training on the WebBoard system, group members had online training on the use of the corresponding tool. After getting an account on the system, each group member was taken into the training conference to perform the training task. Each experimental group had its own training conference. The subjects had two days of training to make sure they knew how to use basic functions of the WebBoard. If they were in the tool support conditions, they had another two days of training to make sure they knew how to use the tool (list gathering and/or voting tool). Since this was an asynchronous experiment, subjects could log on, read training materials and carry out training tasks at any time during the pre-defined time periods, no specific time was scheduled for training. By the end of the training, subjects should have submitted their solutions for the training tasks online to indicate they have finished training session(s) successfully.

During each training session, questions on using the system were encouraged and answered. Group members could also communicate freely with one another using the system during the whole training session.

Previous experiments (e.g., Hiltz et al. 1991) have shown that a designated human leader for a computerized conference can help a group to accomplish its task. Therefore, the groups were asked to elect a coordinator before the end of the training session. A coordinator was responsible to submit the final group report at the end of the experiment. It was up to the groups or the coordinators to determine who should write the group report.

6.6.3.4 Distribute the Experiment Task. After successfully finishing the training session(s), the subjects were put separately into the experimental spaces. For baseline (NN) and Voting Tool support only (NV) groups, a conference called "Discussion Area" was created for each group in the WebBoard system. Two root messages named "Absolute Criteria" and "Relative Criteria" were created as seeds in the conference. Group members discussed their task in that conference under the corresponding root message. For groups with the List Gathering Tool (LN) or the SDSS toolkit (LV) support, a private topic called "Computer purchasing task (Gxxxx)" was created for each group (Gxxxx represents the corresponding group identification number). Under each topic, three lists were created:

- *Absolute Criteria* to discuss all the absolute criteria for the task, that is, minimal specifications that have to be met;
- *Relative Criteria* to discuss all the relative criteria for the task; that is, features that will be used to select from among the alternatives that meet the absolute criteria;
- *Group coordination* to post group meta discussion, for example, any question on the schedule. This list was created so that group members did not need to switch between two systems (the List Gathering Tool/SDSS toolkit and the WebBoard) for coordination purposes. This reduced the confusion of switching between two systems. Hence, it helped groups to focus on their task.

Subjects received the task and the instructions for the experiment in their boards. For groups with the List Gathering Tool/SDSS toolkit support, the task description was posted in their private topic in the tool. For baseline (NN) and Voting Tool support only (NV) groups, the task description was posted in a conference called "Task and Procedures". The subjects were given three days to post their initial individual ideas on the task in a private conference. Only the researchers and the individual who posted the ideas can access it. The subjects were suggested to keep a copy of their posting for their later group discussion. Then, ten days were given for group discussion, and another one day was given for groups to write their group reports.

There was only a little group facilitation to the groups during the performance of the task for groups with voting tool (NV) or SDSS Toolkit (LV) support. After a group decided to start voting, the group coordinator would post a message in the group coordination list in the SDSS toolkit or a message in the voting tool. The investigator would then grant a voting session for them upon their request. The investigator's role was an observer most of the time. Only direct questions regarding experiment process, for instance, "When is the deadline of the task?" and "How to use this function?" were answered.

One day (twenty-four hour) before the deadline, a message was posted to remind groups about the final report due date.

6.6.3.5 Distribute the Post Questionnaires and Collect Feedback. After finishing the experiment task, the subjects received the URL for the "post questionnaire" and the "task survey". Subjects, except those in the baseline condition, were also asked to fill out the "system survey" to give researchers feedback on the system they used. They were asked to finish all the questionnaires within three days. Only those subjects who participated the experimental task and finished all the questionnaires on time were included in the final data analysis.

6.6.3.6 Debriefing. Upon receiving all the finished questionnaires, the questionnaire management system automatically put the subjects into a debriefing conference, where they could find detailed information about the purpose of this experiment, experimental methods, design and hypotheses, and sent them an email with the information for accessing the debriefing conference. A message was also posted in their experimental boards if all group members finished questionnaires.

6.6.3.7 Suggest Grades. After collecting all the reports and post questionnaires, recommended grades for the student subjects were given based on their performance during the participation and their final reports. The performance of each subject was determined according to number of messages/items posted, and quality of those postings. E.g., a subject with 36 messages with simply "Yes, I agree" or "No" was given minimum grade. The investigators then sent the suggested grades to the instructors.

6.6.3.8 Expert Judges and Data Analysis. Two teams of expert judges were formed to examine different aspects of the group work.

One expert judge team of six (one IS faculty, four Ph.D. candidates, and one IS master student) was formed to perform judgment on the quality of the decision-making based on groups' final reports. Before distributing the group reports to expert judges, identifications on the reports were removed. In order to make the judges "blind" to conditions, each group report was assigned a unique identification number which did not have any relationship to the experimental condition. Then, each expert judge was assigned a set of group reports so that at least two judges graded each group report, but no two judges had exactly the same set of reports.

A three-hour training session (Appendix B.9) was conducted to make sure that each judge would have the same/similar criteria in grading the reports. Even after the training session, there was still a great deal of differences among judges on the distribution of scores (e.g., data in Table 6.2). Therefore, before doing the analysis on the grades received from the expert judges, data were standardized so that every judge has a mean of 5.50 on each question to remove individual systematic bias.

Table 6.2 Expert Judgment Raw Data (Partial)

PID*	ReportID*	CR1	CR2	CR3	CR4	CR5	CR6	Present	Creativity	Quality
P1	25	9	8	5	5	2	6	6	7	6
P3	25	1	2	1	3	3	5	6	0	2.5
P4	36	6	3	5	2	3	1	2	5	3
P5	36	9	9	8	8.5	8	8.5	8.5	8.5	9

The standardization procedure was the following:

1. For each question, an average of grades from one single judge on all reports he/she graded was calculated;
2. The original grade was subtracted from the difference between the average and 5.50 (the average point of the scale value).

After finishing the above data transformation, the difference between two judges who graded on the same report was compared. Since the grade range for each question was from 1 to 10, with 1 being poor and 10 being excellent, any report with difference greater than 4 was considered to have an inconsistent rating. In this case, another round of grading by the third judge (tie breaker) was performed until there is a consistent rating on that report.

Another expert team of four from a computer service department in NJIT was formed to examine the quality of all the criteria generated from the group reports. All four judges were in charge of making the RFPs for the university computer purchasing. All the absolute criteria were combined into a comprehensive list of absolute criteria as a master list. The same procedure was carried out on the relative criteria to get the master list of relative criteria. The lists were divided into several categories (13 categories for absolute criteria, 17 categories for relative criteria) as shown in Table 6.3. Only the items that have the same wording were considered as duplications. In this case, only one item was included in the master list. Every item was assigned a unique number in the list. The master lists were then given to expert judges with the instruction on grading (Appendix B.10). Each judge individually gave grades on the items in the list based on the grading policy.

Table 6.3 Absolute and Relative Criteria List Summary

Absolute Category	No. Of Unique items	Relative Category	No. Of Unique items
RAM	19	Memory	4
Keyboard & Mouse	22	Accessories	17
Monitor	13	Monitor	7
Hard Drive	16	Hard Drive	8
Operating System	15	Software	16
Other Software	17	-	
Processor	33	Processor	10
Service	26	Service	39
Removable Storage	33	Storage	5
Multimedia	31	-	
I/O	35	-	
Cabinet	6	-	
		Reputation	35
		Reliability	14
		Warranty	12
		Delivery	6
		Discounts	5

A computer program was utilized to calculate the number of words posted by each group member in the discussion area in the WebBoard conferencing system and/or the contribution in the List Gathering Tool, Voting Tool, or SDSS Toolkit. For groups without any tool support, the length of comments posted in the group discussion area in the WebBoard was calculated, and then summed up as the length of the contribution of the whole group. The same procedure has been carried out for groups with support except that for those groups the comments counted were those posted in the corresponding tools.

The data collected from the post questionnaires and the system monitoring was put into SPSS or SAS (statistical analysis software packages) to conduct the statistical analysis to test the validation of the hypotheses.

A software package called "NVivo" was used to analyze the feedback obtained from the system survey. NVivo was developed by NSR International. It is always used in qualitative research. As the first step, all the answers to the open-ended questions were combined into one word document. Then, a new project was created in NVivo. The document was then imported into the project. The researcher then tried to classify all the comments into different categories by using "coding" function. Figure 6.2 shows a screen shot of data coding process using NVivo.

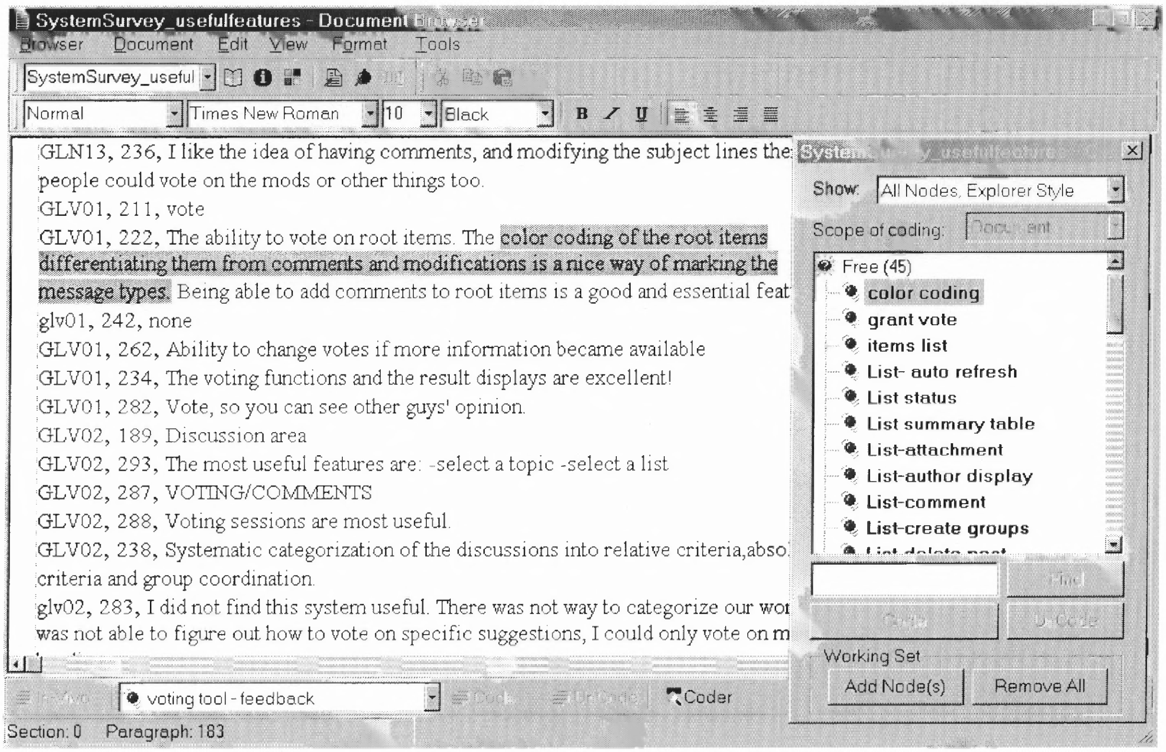

Figure 6.2 NVivo screen shot.

The detailed discussions on the data analysis are presented in the next chapter.

6.7 Research Instruments

Research instruments can be found in Appendix B.

CHAPTER 7

DATA ANALYSIS

7.1 Introduction

This chapter presents the data analyses that are based only on all the individuals who completed the experiment. There were subjects who dropped out during the experiment. For group level analyses, only groups with five members or more were considered as valid data. Groups with fewer than five members were dropped.

Section 7.2 discusses the analyses based on the background questionnaire. In Section 7.3, validity of the scales used in the experiment is discussed. The hypotheses which relate to the post questionnaire are discussed in Section 7.4. Results from the task survey and system survey are presented in Section 7.5 and Section 7.6. Discussion about the results and problems encountered are offered in Section 7.7.

7.2 Individual Characteristics

Students from both undergraduate and graduate programs at NJIT participated in the experiment. A total of 187 students completed the experiment. The number of undergraduate and graduate groups for each condition are displayed in Table 7.1. Seventy-eight (41.7%) of the students were majoring in either computer science or information systems which composed the largest portion of the subjects. Sixty-eight (36.4%) of the students were from the MSIS program. There were 10.2% of the subjects from business or management major.

Table 7.1 Number of Undergraduate and Graduate Groups for Each Condition

		List Gathering Process	
		With List Gathering Tool Support	**Manual**
Voting Process	**With HDV Tool Support**	8 groups (4 grads, 4 under) N=44 (24 grads, 20 under)	8 groups (4 grads, 4 under) N= 45 (22 grad, 23 under)
	Manual	8 groups (5 grads, 3 under) N=46 (29 grads, 17 under)	9 groups (7 grads, 2 under) N=52 (42 grads, 10 under)

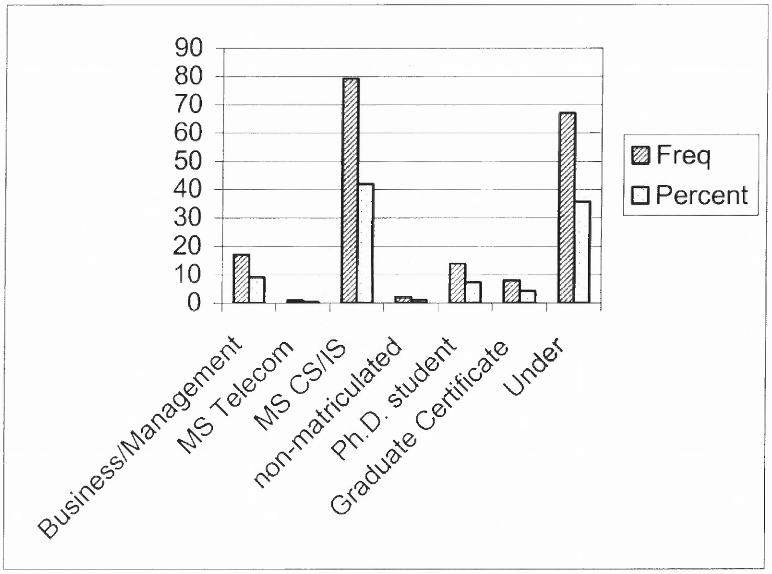

Figure 7.1 Frequency of subjects' current degree program.

Of the experimental population, there were sixty-five (34.8%) females and one hundred twenty-two (65.2%) males.

The subjects' ethnic groups and cultures were diverse. Of the subjects studied, there were 46.2% of the subjects reported that English is their first or native language and 53.8% reported that English is not their native language. Among those subjects who were not born in the U.S., the number of years they have lived in the U.S. is spread fairly evenly from zero to 27 years.

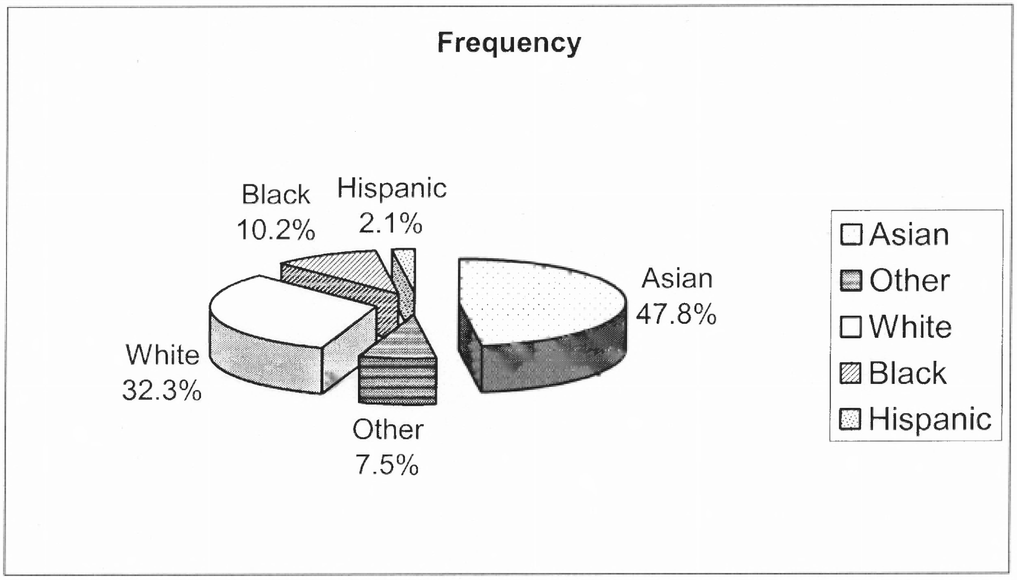

Figure 7.2 Ethnic backgrounds of the subjects.

As to the nationality of the subjects, the largest group is U.S. (33.7%), followed by Indian (25.1%) and Chinese (8.0%). Individuals from other countries such as Poland, Philippine, Nigeria, Greece, Thailand, Russia, Jordan, etc., were also represented.

The ages of the subjects were distributed from under 23 years to over 40. The majority of the subjects (50.5%) were between 23 to 30 years of age. The total number of months of full-time employment ranged from zero to 390 months. Subjects were spread fairly evenly from one to 390, though there were 15.5% of the subjects who didn't have any working experience, and 6.8% of the subjects had 36 months of full-time employment. Table 7.2 shows the frequency and percentage of each category after the researchers break the number of months into six categories.

Table 7.2 Number of Months of Fulltime Employment

	Frequency	Percent
0	29	15.5
1-12	36	19.3
13-48	45	24.1
49-120	39	20.9
121-390	27	14.4
Missing	11	5.9

The majority of the subjects (73.0%) had previously used the WebBoard frequently. Following is the distribution of the frequency of using the WebBoard before they participated the experiment:

Table 7.3 Subjects' WebBoard Experience

	Frequency	Percent
Frequently	136	73.0
Three to ten times	15	8.1
Once or twice	27	14.6
Never	8	4.3

Before participating in the experiment, most subjects (94.1%) reported having the experience of buying a computer. Most of them (70.5%) reported having bought a computer for him/herself. 48.0% of the subjects had bought a computer more than two times. The distribution of their computer purchasing experience is as follows:

Table 7.4 (a) Distribution of Computer Purchasing Experience

	Frequency	Percent
No	11	5.9
Yes	176	94.1

Table 7.4 (b) Distribution of Computer Purchasing Experience

	Frequency	Percent
Myself	124	70.5
Myself, organization	30	17.1
Myself, organization, other	13	7.4
Myself, other	5	2.8
Organization	3	1.7
Organization, other	1	0.6

Table 7.4 (c) Distribution of Computer Purchasing Experience

	Frequency	Percent
Once	60	34.3
Twice	31	17.7
More than two times	84	48.0

The above findings indicate that there would not be much difference in terms of working experience and computer purchasing experience between groups if they were randomly assigned into different groups.

In the self-evaluation section of the background questionnaire, most subjects had positive response to the questions. Most subjects (61.6%) reported high or very high confidence in recommending computers. In terms of the confidence level in contributing in a group, 68.7% of the subjects reported high or very high. Most subjects (92.5%) thought of themselves as average to expert computer users; 98.4% of subjects reported average to very high level group working experience; 79.6% reported average to high or very high level business decision experience; only 11.9% of subjects reported dislike of group discussion; only 16.6% of subjects felt nervous when dealing with new people; 97.9% of subjects had easy access to the WebBoard; 87.1% of subjects were comfortable with group discussion. The detailed distribution of each question can be found in Appendix C.1 (the frequency table for the background questionnaire).

All the above findings indicate that the subjects had some previous computer experience and group working experience before the experiment. Moreover, most subjects had a positive attitude toward group discussion and making business decisions. Therefore, subjects had the necessary skill to carry out the experimental task.

7.3 Scale Validation

Most of the dependent variables in this experiment were measured using a composite variable scale, such as perceived decision quality, perceived decision schema satisfaction, and solution satisfaction, etc. Before summing up all the individual scale variables into their respective composite variable, reliability and validity tests – confirmatory factor analysis and Cronbach's Coefficient Alpha using SAS 8.0 -- were performed. After extracting all the factors, a composite variable was considered reliable if the Cronbach's Coefficient Alpha was equal to or greater than 0.60. In this case, the values of the questions which created the scale were summed to obtain the value of this composite variable, and then the mean value of the composite variable was used for analysis. Otherwise, the composite variable was regarded as unreliable, and the questions were analyzed individually.

7.3.1 Factor Analysis

To ensure the unidimensionality of the scales, confirmatory factor analysis with Promax oblique rotation was used. Promax rotation is a kind of oblique rotation. It allows the factors to be correlated, and it often produces more useful patterns than does orthogonal rotation (Hendrickson and White, 1964).

7.3.1.1 Scales in the Post Questionnaires (Perceived Decision Quality, Decision Schema Satisfaction and Solution Satisfaction). Question 1 through Question 15 (see Appendix B.6) were designed to test perceived quality, decision schema satisfaction, and solution satisfaction. Factor analysis on these questions was performed to test the validity of the scales. Table 7.5 presents factor loadings of Question 1 through Question 15 after Promax rotation.

Table 7.5 Factor Loadings of Q1-Q15 after Promax Rotation

	Factor1 (Decision Schema Satisfaction)	**Factor2 (Solution Satisfaction)**
Q1	0.37271	0.35185
Q2		0.68426
Q3	0.66837	
Q4	0.66334	
Q5	0.85000	
Q6	0.83770	
Q7	0.75510	
Q8	0.76179	
Q9	0.75121	
Q10		0.58817
Q11		0.73278
Q12		0.76679
Q13	0.80517	
Q14		0.67813
Q15		0.40306

Because of the low loading on Question 15 and the joint loading of Question 1, those questions were eliminated in the further analysis. As a result, two factors were extracted:

- Factor 1: decision schema satisfaction (satisfaction on the group process) which includes question 3 through question 9, and question 13
- Factor 2: solution satisfaction which includes question 2, question 10 through question 12, and question 14

The "perceived quality of decision making" dimension disappeared after the factor analysis. Since the loading of Question 1 was low on both factors, it does not belong to either of the factors. It will be analyzed separately as the indicator for perceived quality of decision-making.

7.3.1.2 Scales in Expert Judgment (Quality of Decision-making). There were nine questions in the form (Appendix B.8) that expert judges used to grade the quality of decision making based on their group reports. Table 7.6 shows the results of the factor loadings of all the questions after Promax rotation. Only one factor was extracted, which means that all the questions are related with each other.

Table 7.6 Factor Loadings of Expert Judge Questions after Promax Rotation

	Factor 1 (Quality)
CR1[1]	0.81583
CR2[2]	0.88801
CR3[3]	0.87695
CR4[4]	0.90114
CR5[5]	0.69660
CR6[6]	0.85581
Present	0.83224
Creativity	0.58065
Quality	0.97570

1. CR1: Absolute Criteria Quality (1—10, 1= poor, 10= excellent)
2. CR2: Reasons to support Absolute Criteria selection (1—10, 1= poor, 10= excellent)
3. CR3: Relative Criteria Quality (1—10, 1= poor, 10= excellent)
4. CR4: Reasons to support Relative Criteria selection (1—10, 1= poor, 10= excellent)
5. CR5: Quality of Relative Criteria ranking process (1—10, 1= poor, 10= excellent)
6. CR6: Quality of Relative Criteria ranking orders (1—10, 1= poor, 10= excellent)

7.3.2 Reliability of the Process Gain (Level of Understanding) Index

Questions 16 through 18 (see Appendix B.6) were designed to test the level of understanding. The Cronbach Coefficient Alpha of the level of understanding was 0.33, as shown in Table 7.7 below. This is too low to be considered reliable. Correlations between any two of the three questions have also been tested. None of them had Cronbach Coefficient Alpha greater than 0.60. Therefore, the analyze will use each individual question.

Table 7.7 Reliability of Process Gain (Level of Understanding)

Cronbach Coefficient Alpha

Variables	Alpha
Raw	0.32
Standardized	0.33

Cronbach Coefficient Alpha with Deleted Variable

	Raw Variables Correlation with Total	Alpha	Standardized Variables Correlation with Total	Alpha
Q16 (Better understand other members position)	0.261227	0.081059	0.261294	0.081084
Q17 (Uncovered valid alternatives)	0.145922	0.320988	0.147816	0.321217
Q18 (Critically reevaluate the validity of the alternatives)	0.148448	0.312967	0.151677	0.299040

7.3.3 Reliability of the Process Loss (Information Overload) Index

The Cronbach Coefficient Alpha of the information overload was 0.63, as shown in Table 7.8 below. Since it is greater than 0.60, the questions in this scale will be summed up into a composite variable. The analysis of variance for this variable will be conducted to test the significance.

Table 7.8 Reliability of the Process Loss (Information Overload) Scale

Cronbach Coefficient Alpha

Variables	Alpha
Raw	0.63
Standardized	0.63

Cronbach Coefficient Alpha with Deleted Variable

	Raw Variables Correlation with Total	Raw Variables Alpha	Standardized Variables Correlation with Total	Standardized Variables Alpha
Q25 (System resulted Information Overload)	0.395990	0.600259	0.392695	0.601135
Q26 (System increased Irrelevant Information)	0.538613	0.390678	0.539118	0.391707
Q27 (System caused Missing information)	0.398544	0.591979	0.399452	0.592035

7.3.4 Reliability of Solution Satisfaction Index

The Cronbach Coefficient Alpha of the solution satisfaction was 0.77, as shown in Table 7.9 below. Since it is greater than 0.60, the questions in this scale will be summed up into a composite variable. The analysis of variance for this variable will be conducted to test the significance.

Table 7.9 Reliability of the Solution Satisfaction Scale

Cronbach Coefficient Alpha

Variables	**Alpha**
Raw	0.77
Standardized	0.77

Cronbach Coefficient Alpha with Deleted Variable

	Raw Variables		**Standardized Variables**	
Deleted Variable	**Correlation with Total**	**Alpha**	**Correlation with Total**	**Alpha**
Q2 (Trivial/Substantial)	0.442737	0.762724	0.441281	0.763543
Q10 (Very dissatisfied/Very satisfied with the quality of solution)	0.590847	0.710491	0.590448	0.713013
Q11 (Extent to reflect your input)	0.512683	0.738223	0.513556	0.739557
Q12 (feeling committed to the group solutions)	0.542985	0.727841	0.545647	0.728609
Q14 (Confident)	0.626860	0.699408	0.626939	0.700039

7.3.5 Reliability of the Decision Schema Satisfaction Index

Decision schema refers to the complexity of the group process. The decision schema satisfaction scale is reliable at 0.92 as shown in Table 7.10. Since this scale is reliable, the questions in this scale will be summed up into a composite variable. The analysis of variance for this variable will be conducted to test the significance.

Table 7.10 Reliability of Decision Schema Satisfaction Scale

Cronbach Coefficient Alpha

Variables	**Alpha**
Raw	0.92
Standardized	0.92

Cronbach Coefficient Alpha with Deleted Variable

Deleted Variable	**Raw Variables** Correlation with Total	**Raw Variables** Alpha	**Standardized Variables** Correlation with Total	**Standardized Variables** Alpha
Q3(Work Content: CarefullyD/CarelesslyD)	0.715931	0.906540	0.714074	0.907861
Q4 (Examine mannerNon-constructive/constructive)	0.683908	0.908910	0.684495	0.910268
Q5(Efficient/Inefficient)	0.821049	0.897543	0.818467	0.899193
Q6(Coordinated/Uncoordinated)	0.798613	0.899287	0.801308	0.900636
Q7(Fair/Unfair)	0.711848	0.906926	0.710487	0.908154
Q8(Understandable/Confusing)	0.778193	0.901350	0.779808	0.902434
Q9(Satisfying/Unsatisfying)	0.801788	0.898989	0.803784	0.900428
Q13(ThoroughlyDiscussed/N)	0.510697	0.924055	0.510349	0.924017

7.3.6 Reliability of the Quality of Decision Making Index

The quality of decision making scale used by the expert judges for assessing quality of the group reports had high correlation at 0.94 as shown in Table 7.11 below. Therefore, the scale was reliable, and the analysis of variance will be based on a composite variable which sums up all the questions in this scale to test the significance.

Table 7.11 Reliability of Quality of Decision Making Scale

Cronbach Coefficient Alpha

Variables	Alpha
Raw	0.94
Standardized	0.94

Cronbach Coefficient Alpha with Deleted Variable

Deleted Variable	Raw Variables: Correlation with Total	Raw Variables: Alpha	Standardized Variables: Correlation with Total	Standardized Variables: Alpha
CR1[1]	0.752994	0.931168	0.754455	0.935861
CR2[2]	0.839236	0.926312	0.842009	0.930908
CR3[3]	0.818444	0.927509	0.826268	0.931807
CR4[4]	0.851757	0.925716	0.857169	0.930039
CR5[5]	0.631309	0.942940	0.632166	0.942596
CR6[6]	0.807570	0.927958	0.810784	0.932687
Present	0.784180	0.929425	0.785161	0.934137
Creativity	0.517489	0.943323	0.515058	0.948848
Quality	0.969846	0.919395	0.967017	0.923642

Note:

1. CR1: Absolute Criteria Quality (1—10, 1= poor, 10= excellent)
2. CR2: Reasons to support Absolute Criteria selection (1—10, 1= poor, 10= excellent)
3. CR3: Relative Criteria Quality (1—10, 1= poor, 10= excellent)
4. CR4: Reasons to support Relative Criteria selection (1—10, 1= poor, 10= excellent)
5. CR5: Quality of Relative Criteria ranking process (1—10, 1= poor, 10= excellent)
6. CR6: Quality of Relative Criteria ranking orders (1—10, 1= poor, 10= excellent)

7.4 Hypotheses Testing

Before doing the ANOVA analysis on each variable, a check on the normal distribution of each variable was performed. The ANOVA was conducted only when the values of the variable are normally distributed. If the values of the variable are not normally distributed, data transformation was performed to test the normality. If all those efforts failed, a non-parametric ANOVA was conducted.

7.4.1 Perceived Quality of Decision-making

Since only the first question in the post questionnaire was identified as the measure of perceived quality of decision-making after the confirmatory factor analysis, only this question (the overall quality of the group's work: poor (1) ----- good (5)) was analyzed using nested ANOVA.

The normal distribution test on this question shows that the data was not normally distributed even after various data transformation. Non-parametric ANOVA was carried out to test the significance. Overall, no significant effect was found for this factor.

H1a. Groups supported by the List Gathering Tool, compared to groups not supported by the List Gathering Tool, will have higher perceived quality of decision-making.

Not supported.

H1b. Groups supported by both the list gathering and the voting tool will have disproportionately higher perceived quality of decision-making.

Not supported.

7.4.2 Process Gain (Level of Understanding)

Since the scale of process gains (level of understanding) was not reliable with a Cronbach's Alpha of less than 0.60, each question which composes this scale was analyzed individually.

The analysis of the effects of the presence of the tools on the ability to uncover valid alternatives is presented in Table 7.12 below. Only mean values with significant result are presented.

Table 7.12 Three-way ANOVA on the Process Gains (Level of Understanding)

The group decision process uncovered valid alternatives that I had not considered. Strongly Disagree – Strongly Agree (Process gain)

Means*

		List Gathering Process		
		With List Gathering Tool Support	**Manual**	
Voting Process	**With HDV Tool Support**	**3.55**	2.73	3.13
	Manual	3.04	3.17	3.11
		3.29	2.97	3.12

*: Only mean values with significant result are presented in the above table.

Source	DF	Sum of Square	Mean Square	F Value	Pr>F
Model	7	23.99	3.43	2.51	0.02
Error	179	244.19	1.36		
Corrected Total	186	268.17			

Source	DF	Type III SS	Mean Square	F Value	Pr>F
ListTool	1	9.04	9.04	6.62	**0.01**
VotingTool	1	1.13	1.13	0.83	0.36
Ltool*Vtool	1	5.10	5.10	3.74	**0.05**
Degree	1	0.07	0.07	0.05	0.83
LTool*Degree	1	0.88	0.88	0.64	0.42
VTool*Degree	1	6.78	6.78	4.97	0.03
LTool*Vtool*Degree	1	2.21	2.21	1.62	0.20

In examining the ability to uncover alternatives, the presence of the List Gathering Tool does show a significant effect. The groups with the List Gathering Tool support reported significantly higher ability (mean=3.29, which means they agree more with the statement that they uncovered valid alternatives which they had not considered) to uncover the alternatives than groups without the List Gathering Tool support (mean=2.97, which means they are not quite sure whether they uncovered valid alternatives which they had not considered). An interaction between the presence of the List Gathering Tool and the voting tool was also found. Groups with both the List Gathering Tool and the voting tool reported the highest ability to uncover the alternatives (mean=3.55).

There was no significant effect of the degree program on this question. The analyses of all the other questions meaning process gains related to the level of understanding did not find any significant result.

H2a. Groups with the List Gathering Tool support, compared to groups without the List Gathering Tool support, will have higher level of understanding on the task.

Supported only on the analysis of the ability to discover valid alternatives.

H2b. Groups with both the list gathering and the voting tool support will have disproportionately higher level of understanding on the task.

Supported only on the analysis of the ability to discover valid alternatives.

7.4.3 Process Loss (Information Overload)

Since the scale of process loss (information overload) was reliable with a Cronbach's Alpha of greater than 0.60, the values of each individual question were summed up into a composite variable.

Overall, no significant effect was found for this factor.

H3a. Groups with the List Gathering Tool support, compared to groups without the List Gathering Tool support, will have lower information overload.

Not supported.

H3b. Groups with both the list gathering and the voting tool support will have disproportionately lower level of information overload.

Not supported.

7.4.4 Solution Satisfaction

Since the scale of solution satisfaction was reliable with a Cronbach's Alpha of greater than 0.60, the values of each individual question were summed up into a composite variable.

There was a significant interaction effect between subjects' degree program and the presence of the List Gathering Tool. The mean value of this scale (19.19) for the whole subject groups indicates that subjects were satisfied with their solution overall, in which undergraduate subject groups in manual condition (with a mean of 19.79), and graduate subject groups in list gathering support condition (with a mean of 19.57) reported significantly higher satisfaction with the solution. This suggests that graduate subjects tend to appreciate the tool, while undergraduates tends to prefer to work manually. Table 6.13 presents the three-way ANOVA result on this factor. Only means with significant result are presented here.

H4a. Groups with the List Gathering Tool support, compared to groups without the List Gathering Tool support, will be more satisfied with their solutions.

Not supported (only supported for graduate students).

H4b. Groups with both the list gathering and the voting tool support will be disproportionately more satisfied with their solutions.

Not supported.

Table 7.13 Three-way ANOVA on the Solution Satisfaction

Means*

		List Gathering Process	
		With List Gathering Tool Support	**Manual**
Degree	**Graduate**	**19.57**	19.25
	Under	18.11	**19.79**

*: Only mean values with significant result are presented in the above table.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	91.223967	13.031995	1.02	0.4177
Error	179	2283.845552	12.758914		
Corrected Total	186	2375.069519			

R-Square	Coeff Var	Root MSE	Mean
0.038409	18.61123	3.571962	19.19251

Source	DF	Type III SS	Mean Square	F Value	Pr > F
DEGREE	1	3.62146310	3.62146310	0.28	0.5949
LTOOL	1	25.88201674	25.88201674	2.03	0.1561
VTOOL	1	1.59468658	1.59468658	0.12	0.7241
DEGREE*LTOOL	1	51.47440336	51.47440336	4.03	**0.0461**
DEGREE*VTOOL	1	4.44349954	4.44349954	0.35	0.5558
LTOOL*VTOOL	1	14.78090898	14.78090898	1.16	0.2832
DEGREE*LTOOL*VTOOL	1	12.11831633	12.11831633	0.95	0.3311

7.4.5 Decision Schema Satisfaction

There were eight questions in the scale of decision schema satisfaction. Since this scale was reliable with a Cronbach's Alpha greater than 0.60, the values of each individual question were summed up into a composite variable. The range of this factor is from 8 (very dissatisfied) to 40 (very satisfied).

Table 7.14 below shows the analysis on the decision schema satisfaction. Only means with significant result are presented here.

Table 7.14 Three-way ANOVA on the Decision Schema Satisfaction

Means*

Degree = Graduate		List Gathering Process	
		With List Gathering Tool Support	**Manual**
Voting Process	**With HDV Tool Support**	17.96	19.09
	Manual	20.20	20.14

Degree = Under		List Gathering Process	
		With List Gathering Tool Support	**Manual**
Voting Process	**With HDV Tool Support**	20.70	19.70
	Manual	17.47	21.90

*: Only mean values with significant result are presented in the above table.

Source	DF	Sum of Squares	Mean Square	F Value	Pr> F
Model	7	46.4558589	6.6365513	1.44	0.2331
Error	25	115.0318027	4.6012721		
Corrected Total	32	161.4876617			

Source	DF	Type III SS	Mean Square	F Value	Pr> F
LTool	1	9.05099510	9.05099510	1.97	0.1731
VTool	1	2.35594717	2.35594717	0.51	0.4809
LTool*VTool	1	9.64305512	9.64305512	2.10	0.1601
Degree	1	1.35793477	1.35793477	0.30	0.5918
LTool*degree	1	2.16192821	2.16192821	0.47	0.4994
VTool*degree	1	8.12429926	8.12429926	1.77	0.1959
LTool*VTool*degree	1	23.02471866	23.02471866	5.00	0.0344

There was no significant difference between groups with tool support and groups without tool support. But while taking the degree program into account, a significant three-way interaction was found. The graduate student groups having access to both the List Gathering Tool and the voting tool reported significantly lower satisfaction toward the group decision making process (with a mean of 17.96), while the undergraduate students groups having no access to either the List Gathering Tool or the voting tool reported significantly higher satisfaction (with a mean of 21.90). With eight questions in this scale, a mean of around 20 indicates that subjects were not so satisfied with the group process. Although there was a significant three-way effect, mean values of all conditions were actually very close (from 17.47 to 21.90). For graduate students, groups with one of the tool support (either the List Gathering Tool or the voting tool) even reported almost the same level of satisfaction towards the group decision making process as those manual groups. Therefore, there were no big difference in terms of the level of satisfaction towards decision schema among conditions.

H5a. Groups with the List Gathering Tool support, compared to groups without the List Gathering Tool support, will report higher level of satisfaction with their group process.

Not supported.

H5b. Groups with both list-gathering and voting tool support will report disproportionately higher level of satisfaction with their group process.

Not supported.

7.4.6 Quality of Decision-making (Report)

Six people from Information Systems department – one IS faculty, four Ph.D. candidates, and one IS master student – served as expert judges to grade the group reports. Even though there was a training session for them to agree on a grading standard, there was still a great deal of difference among judges on the distribution of scores. Therefore, before doing the analysis on the grades received from the expert judges, data were standardized so that every judge has a mean of 5.50 on each question to remove individual systematic bias. The standardization procedure is the following:

1. For each question, an average of grades from one single judge on all reports he/she graded was calculated;
2. The original grade was subtracted from the difference between the average and 5.50 (the average point of the scale value).

After finishing the above data transformation, the difference between two judges who graded on the same report was compared. Since the grade range for each question was from 1 to 10, with 1 being poor and 10 being excellent, any report with difference greater than 4 was considered to have an inconsistent rating. In this case, another round of grading by the third judge (tie breaker) was performed until there is a consistent rating on that report.

Table 7.15 presents three-way ANOVA results on the quality of decision making based on group reports. Only means with significant difference are presented there.

Three effects were found through the analysis:

- Significant difference were found between the mean value of groups with the List Gathering Tool support and that of groups without the List Gathering Tool support ($p=0.0043$, $p<0.005$). The reports of groups without the List Gathering Tool (mean=54.27) had significantly higher quality than groups with the List Gathering Tool support (mean=44.43).
- Significant two-way interaction effect (List Tool x Voting Tool, $p=0.0140$, $p<0.01$). Reports of those groups without any tool support (mean=59.04) had significantly higher quality than those with tool support.

- Significant difference between the mean value of graduate groups and that of undergraduate groups ($p=0.04$, $p<0.05$). Reports of graduate groups (mean=52.74) had significantly higher quality than those undergraduate groups (mean=44.52).

The tool(s) were designed to improve the quality of groups' decision making by providing extra technical support to their process. Surprisingly, the results from this experiment showed opposite effects. Since most student subjects were very familiar with the WebBoard system, it was clear that subjects in the manual condition (NN) did not have as many distractions as other conditions had. It might be easier for groups in manual condition to focus on the experimental task. For tool-supported groups, subjects might need to spend more time learning the system. Therefore, they might spend less time on the task than those groups in manual condition.

Another possible explanation for this result is that the number of items proposed by group members were too small to make the effectiveness of the List Gathering Tool visible. Since the number of items in each criteria list proposed by each group was very limited, subjects were able to comb through the comments posted in the WebBoard conference fairly easily. However, if there were more items in the list, it would be too difficult for groups to collect all the ideas into a list after vigorous discussions in a WebBoard conference.

Moreover, the subsidiary result that graduate groups did significantly better than undergraduate groups seems to suggest that the proportion of graduate groups in the manual condition (7 out of 9 groups) was greater than that in all other conditions (4 or 5 out of 8 groups) may be one of the factors that have contributed to those unexpected results.

Since the experiment was carried out over two semesters (seven groups of graduate students in manual condition in Spring 2002, all other groups in Fall 2002), the researchers are concerned whether there is a difference in terms of group performance over time. A one-way ANOVA analysis comparing the means of graduate groups' performance over time revealed such a significant difference. Appendix C.3 presents the ANOVA result. After Spring 2002, the economy in the U.S. slowed down. It resulted in the shrinkage of the student body in the university. The result also suggests that the economy down turn might have played a role here.

H7a. Groups with the List Gathering Tool support, compared to groups without the List Gathering Tool support, will have higher quality of decision-making.

Not Supported.

H7b. Groups with both the list gathering and the voting tool support will have disproportionately higher quality of decision-making.

Not Supported.

Table 7.15 Three-way ANOVA on the Quality of Decision-making (Group Reports)

Means*

		List Gathering Process		
		With List Gathering Tool Support	**Manual**	
Voting Process	**With HDV Tool Support**	47.57	48.91	48.24
	Manual	41.29	**59.04**	50.69
		44.43	**54.27**	49.50

Degree	Quality
Graduate	**52.74**
Undergraduate	44.52

*: Only mean values with significant result are presented in the above table.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	3586.69491	512.38499	3.65	0.0025
Error	58	8132.66873	140.21843		
Corrected Total	65	11719.36364			

R-Square	Coeff Var	Root MSE	TotalQual Mean
0.306049	23.92199	11.84139	49.50000

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LTool	1	1237.006238	1237.006238	8.82	**0.0043**
VTool	1	6.320475	6.320475	0.05	0.8326
Degree	1	637.178144	637.178144	4.54	**0.0373**
LTool*VTool	1	899.789481	899.789481	6.42	**0.0140**
Degree*LTool	1	52.194603	52.194603	0.37	0.5442
Degree*VTool	1	0.046952	0.046952	0.00	0.9855
Degree*LTool*VTool	1	91.033500	91.033500	0.65	0.4237

7.4.7 Quality of Decision-making (Criteria Lists)

In order to judge the quality of criteria generated by groups, the researchers organized two master lists for criteria presented in all group reports, one for absolute criteria and one for relative criteria. The master lists were then given to expert judges with the instruction on grading (Appendix B.10). Four persons from a computer service department in NJIT were invited to serve as judges in evaluating the quality of criteria. All four judges were in charge of making the RFP for the university computer purchasing. They were asked to assign grade for each criterion in the list.

The grades from each judge were collected and stored into a database. There were some missing values. The grades were not consistent among judges with correlation of any two experts from 0.01 to 0.47 for absolute criteria, and 0.03 to 0.27 for relative criteria (Appendix C.4). In this case, the average grade from all judges was used as the grade for each criterion. The grade for each group was calculated by averaging all the grades for the criteria in its list. The grade for each criterion ranged from 0 to 4. The meaning of each grade for relative criteria and absolute criteria is presented as footnotes in Table 7.16a and Table 7.16b accordingly.

For relative criteria, there is a significant difference between groups with the voting tool support (mean = 2.02) and groups without the voting tool support (mean = 2.29). The grades of those without voting tool support were significantly higher than groups with the voting tool support. Table 7.16a shows the three-way ANOVA result on the relative criteria.

Table 7.16a Three-way ANOVA on Relative Criteria List

Means*

VTool	Relative	Absolute
VTool	2.02	1.94
NoVTool	**2.29**	1.95

*: Only mean values with significant result are presented in the above table.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	1.00484450	0.14354921	0.87	0.5464
Error	24	3.97707274	0.16571136		
Corrected Total	31	4.98191724			

R-Square	Coeff Var	Root MSE	Mean
0.201698	18.79914	0.407077	2.165400

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Degree	1	0.02916237	0.02916237	0.18	0.6786
Ltool	1	0.06473542	0.06473542	0.39	0.5379
Vtool	1	0.67956060	0.67956060	4.10	**0.0541**
Degree*Ltool	1	0.02343643	0.02343643	0.14	0.7102
Degree*Vtool	1	0.14221072	0.14221072	0.86	0.3635
Ltool*Vtool	1	0.14041115	0.14041115	0.85	0.3665
Degree*Ltool*Vtool	1	0.00385891	0.00385891	0.02	0.8800

Notes: The scale for relative criteria: A=4, B=3, C=2, D=1, F=0

A A nice-to-have feature valid in the past year and well representing a well specified statement of the requirement.

B A nice-to-have feature valid in the past year but not the best possible statement of the requirement in the set of related statements you have.

C Should be an absolute requirement not a relative (maybe a must have for today)

D Poorly states, incomplete, too low performance, or under specified as a relative requirement

F Completely wrong, ambiguous, or meaningless.

For absolute criteria, there is a significant interaction between degree program and presence of the List Gathering Tool. The absolute criteria collected by the undergraduate student groups without the List Gathering Tool process (mean=2.12) had significantly higher quality. Although undergraduate groups without the List Gathering Tool support had highest grade mean on absolute criteria quality, absolute criteria quality grades of all groups were actually very close (from mean value of 1.75 for undergraduate group with the List Gathering Tool support to 2.12 for undergraduate group without the List Gathering Tool support). According to the grading scale, all of these grades suggest that the quality of all the groups was not so good. Most of them included criteria that should be relative criteria rather than absolute criteria, or the criterion was poorly stated. Table 6.16(b) shows the three-way ANOVA result on the absolute criteria.

Table 7.16b Three-way ANOVA on Absolute Criteria List

Means*

		List Gathering Process	
		With List Gathering Tool Support	**Manual**
Degree	**Graduate**	**1.98**	1.94
	Under	1.75	**2.12**

*: Only mean values with significant result are presented in the above table.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	0.51625091	0.07375013	1.07	0.4087
Error	25	1.71717333	0.06868693		
Corrected Total	32	2.23342424			

R-Square	Coeff Var	Root MSE	Mean
0.231148	13.47570	0.262082	1.944848

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Degree	1	0.00849096	0.00849096	0.12	0.7281
Ltool	1	0.17323638	0.17323638	2.52	0.1248
Vtool	1	0.00178839	0.00178839	0.03	0.8731
Degree*Ltool	1	0.27358457	0.27358457	3.98	**0.0570**
Degree*Vtool	1	0.05255697	0.05255697	0.77	0.3900
Ltool*Vtool	1	0.04508713	0.04508713	0.66	0.4255
Degree*Ltool*Vtool	1	0.04066420	0.04066420	0.59	0.4488

Notes: The scale for absolute criteria: A=4, B=3, C=2, D=1, F=0

A. A necessary minimum requirement valid in the past year and well representing a well specified statement of the requirement.

B A necessary minimum requirement valid in the past year but not the best possible statement of the requirement in the set of related statements you have.

C Should be a relative requirement not an absolute (maybe too expensive, and/or not of sufficient value relative to the other necessary requirements)

D Poorly states, incomplete, too low performance, or over specified as an absolute requirement

F Completely wrong, ambiguous, or meaningless.

7.4.8 Total Words of Comments

A computer program has been made available to calculate total words of comments contributed by each group member. For groups without any tool support, total words of comments posted in the group discussion area in the WebBoard was calculated, and then summed up as total words of the contribution of the whole group. The same procedure has been carried out for groups with support except that for those groups the comments counted were those posted in the corresponding tools.

The ANOVA analysis on groups' contribution showed that groups with the voting tool support made significantly shorter comments than groups without the voting tool support. Table 7.17 shows the three-way ANOVA on total words of comments. Only mean values with significant result are displayed here.

Table 7.17 Three-way ANOVA on Total Words of Comments

Means*

		List Gathering Process		
		With List Gathering Tool Support	**Manual**	
Voting Process	**With HDV Tool Support**	3688.75	4436.00	**4062.38**
	Manual	6232.75	8190.44	7269.18
		4960.75	6423.65	5714.36

*: Only mean values with significant result are presented in the above table.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	136437091.3	19491013.0	2.05	0.0886
Error	25	238047380.3	9521895.2		
Corrected Total	32	374484471.6			

R-Square	Coeff Var	Root MSE	Mean
0.364333	54.00001	3085.757	5714.364

Source	DF	Type III SS	Mean Square	F Value	Pr > F
DEGREE	1	11568565.39	11568565.39	1.21	0.2809
LTOOL	1	4960608.95	4960608.95	0.52	0.4771
VTOOL	1	44698468.59	44698468.59	4.69	**0.0400**
DEGREE*LTOOL	1	6433668.93	6433668.93	0.68	0.4189
DEGREE*VTOOL	1	17479248.32	17479248.32	1.84	0.1876
LTOOL*VTOOL	1	40427.16	40427.16	0.00	0.9486
DEGREE*LTOOL*VTOOL	1	3020392.02	3020392.02	0.32	0.5783

The comparison between coordinators in different condition did not show any significant result. Table 7.18 shows the three-way ANOVA results comparing total words of comments contributed by coordinators. Since there is no significant result, the mean value table is not presented.

Table 7.18 Three-way ANOVA on Total Words of Coordinators' Comments

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	26662730.51	3808961.50	1.50	0.2137
Error	25	63599553.37	2543982.13		
Corrected Total	32	90262283.88			

Source	DF	Type III SS	Mean Square	F Value	Pr > F
DEGREE	1	4746536.475	4746536.475	1.87	0.1841
LTOOL	1	1492537.084	1492537.084	0.59	0.4509
VTOOL	1	7022531.363	7022531.363	2.76	0.1091
DEGREE*LTOOL	1	1538153.128	1538153.128	0.60	0.4441
DEGREE*VTOOL	1	3068073.105	3068073.105	1.21	0.2826
LTOOL*VTOOL	1	919756.218	919756.218	0.36	0.5531
DEGREE*LTOOL*VTOOL	1	889667.859	889667.859	0.35	0.5596

Table 7.19 One-way ANOVA on Total Words of Comments

Means

Role	Comment Length
Coordinator	**2295.39**
Member	737.42

Source	DF	Type III SS	Mean Square	F Value	Pr > F
ROLE	1	65888573.90	65888573.90	73.56	**<.0001**

The comparison between total words of comments of individual group members and the coordinators showed a significant difference as Table 7.19 shows. Overall, the coordinators made significantly longer comments (in total) than group members. Taking the degree program into account, the coordinators in graduate student groups made the longest comments (in total), while the members in undergraduate student groups made the shortest comments as shown in Table 7.20. Individual postings in the list gathering supported groups were significantly shorter than in groups without the List Gathering Tool support (Table 7.21). When analyzing the data from graduate and undergraduate groups separately, the researchers found that the coordinators in graduate groups without any tool support made the longest comments, groups with the List Gathering Tool support made significantly shorter comments, groups with the voting tool support also made significantly shorter comments; while in undergraduate groups, only the role of members (coordinator or member) had a significant effect (Table 7.22).

Table 7.20 Two-way ANOVA on Total Words of Comments (Degree x Role)

Means

		Role		
		Coordinator	**Member**	
Degree	**Graduate**	2694.80	781.66	**1111.51**
	Under	1680.92	662.93	851.99
		2295.39	737.42	1013.84

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Degree	1	8282286.30	8282286.30	9.65	**0.0022**
Role	1	55471101.83	55471101.83	64.63	**<.0001**
Role * Degree	1	5173526.42	5173526.42	6.03	**0.0150**

Table 7.21 Three-way ANOVA on Total Words of Comments (List x Voting x Role)

Means

Coordinator		List Gathering Process		
		With List Gathering Tool Support	**Manual**	
Voting Process	**With HDV Tool Support**	1229.63	2033.88	**1631.75**
	Manual	2728.13	3090.56	2920.00
		1978.88	2593.29	**2295.39**

Member		List Gathering Process		
		With List Gathering Tool Support	**Manual**	
Voting Process	**With HDV Tool Support**	546.47	533.81	**540.14**
	Manual	737.82	1067.42	912.79
		644.73	824.25	737.42

Source	DF	Type III SS	Mean Square	F Value	Pr > F
List	1	3722895.89	3722895.89	4.72	**0.0312**
Role	1	74947234.03	64946234.03	82.28	**<.0001**
VTool	1	18197908.37	18197908.37	23.05	**<.0001**
LTool*Role	1	1221276.76	1221276.76	1.55	0.2152
LTool*Vtool	1	16761.76	16761.76	0.02	0.8843
VTool*Role	1	5665600.21	5665600.21	7.18	**0.0081**
LTool*VTool*Role	1	1039843.79	1039843.79	1.32	0.2526

Table 7.22 Three-way ANOVA on Total Words of Comments

(a) Graduate: List x Voting x Role

Means

Coordinator		List Gathering Process: With List Gathering Tool Support	List Gathering Process: Manual	
Voting Process	With HDV Tool Support	905.75	2515.25	**1710.50**
	Manual	3230.60	3437.00	3351.00
		2197.33	3101.82	**2694.80**

Member		List Gathering Process: With List Gathering Tool Support	List Gathering Process: Manual	
Voting Process	With HDV Tool Support	498.40	452.76	**477.43**
	Manual	720.75	1145.03	972.44
		619.68	917.71	781.66

Source	DF	Type III SS	Mean Square	F Value	Pr > F
List	1	4712723.11	4712723.11	5.10	**0.0260**
Role	1	51742851.95	51742851.95	55.96	**<.0001**
VTool	1	16944302.60	16944302.60	18.32	**<.0001**
LTool*Role	1	2021400.28	2021400.28	2.19	0.1422
LTool*Vtool	1	852158.11	852158.11	0.92	0.3392
VTool*Role	1	5321518.21	5321518.21	5.75	**0.0182**
LTool*VTool*Role	1	3432935.23	3432935.23	3.71	**0.0566**

Table 7.22 Three-way ANOVA on Total Words of Comments (Continued)

(b) Undergraduate: List x Voting x Role

Means

Coordinator		**List Gathering Process**		
		With List Gathering Tool Support	**Manual**	
Voting Process	**With HDV Tool Support**	1553.50	1552.50	1553.00
	Manual	1890.67	1878.00	1885.60
		1698.00	1661.00	**1680.92**

Member		**List Gathering Process**		
		With List Gathering Tool Support	**Manual**	
Voting Process	**With HDV Tool Support**	606.56	606.32	606.43
	Manual	767.07	727.88	752.82
		681.47	642.33	**662.93**

Source	**DF**	**Type III SS**	**Mean Square**	**F Value**	**Pr > F**
List	1	1714.79	1714.79	0.00	0.9522
Role	1	10555438.39	10555438.39	22.31	**<.0001**
VTool	1	542602.83	542602.83	1.15	0.2883
LTool*Role	1	403.93	403.93	0.00	0.9768
LTool*Vtool	1	1557.56	1557.56	0.00	0.9544
VTool*Role	1	88063.60	88063.60	0.19	0.6676
LTool*VTool*Role	1	452.53	452.53	0.00	.09754

7.4.9 Equality of Participation

For each group, as described in the previous section, a software program was utilized to calculate each member's contribution. The equality of participation was calculated using the standard deviation of members' percentaged word counts. Since the original data were not normally distributed, data transformation was performed to ensure normal distribution. As the result, the reciprocal of the original data was used for further analysis. The three-way ANOVA result in Table 7.23 shows that there is no significant effect of either the tool(s) or the degree program on the equality of participation.

Table 7.23 Three-way ANOVA on Equality of Participation

Means

Degree=Graduate		List Gathering Process: With List Gathering Tool Support	List Gathering Process: Manual	
Voting Process	With HDV Tool Support	8.01	4.45	6.23
	Manual	8.43	7.64	7.97
		8.25	6.48	7.27

Degree=Under		List Gathering Process: With List Gathering Tool Support	List Gathering Process: Manual	
Voting Process	With HDV Tool Support	7.56	6.19	6.87
	Manual	8.05	6.23	7.32
		7.77	6.20	7.05

R-Square	Coeff Var	Root MSE	Mean
0.181893	41.92409	3.011876	7.184118

Source	DF	Type III SS	Mean Square	F Value	Pr > F
DEGREE	1	0.11946189	0.11946189	0.01	0.9096
LTOOL	1	26.14857030	26.14857030	2.88	0.1020
VTOOL	1	7.85525074	7.85525074	0.87	0.3610
DEGREE*LTOOL	1	0.62300074	0.62300074	0.07	0.7954
DEGREE*VTOOL	1	4.36204783	4.36204783	0.48	0.4944
LTOOL*VTOOL	1	2.46507340	2.46507340	0.27	0.6068
DEGREE*LTOOL*VTOOL	1	4.74504952	4.74504952	0.52	0.4762

7.5 Task Survey

After subjects completed the experimental task, the researchers distributed a task survey along with the post-questionnaire. This section discusses the results from the task survey.

There are ten five-point semantic differential questions in the task survey. Overall, subjects reported that they needed a little more than average effort, with an average of 3.29, to finish the task, in which 37.8% of the subjects thought they needed a lot of effort. This suggested that it is not an easy task. When comparing the means between the undergraduate and graduate groups, the undergraduate groups reported significantly more effort. Table 6.24 shows the ANOVA result comparing the means between graduate and undergraduate groups. Three-way ANOVA was utilized to further analyze the data. The result indicates that the groups without any tool support reported that they needed significantly more effort to carry out the task. This may actually suggest that the toolkit to some extent reduced the effort needed to carry out the task. Table 6.25 shows the three-way ANOVA result. Only means with significant results are presented here.

Table 7.24 One-way ANOVA on the Effort Needed to Finish the Task

How much effort was required to complete this task?
Very Little Effort (1) ------- Extraordinary Effort (5)

Means

Graduate	**3.19**
Undergraduate	**3.46**

Source	DF	Sum of Squares	Mean Square	F Value	Pr> F
Model	1	3.35	3.35	5.29	0.02
Error	185	117.06	0.63		
Corrected Total	186	120.41			

Source	DF	Type III SS	Mean Square	F Value	Pr> F
Degree	1	3.35	3.35	5.29	**0.02**

Table 7.25 Three-way ANOVA on the Effort Needed to Finish the Task

How much effort was required to complete this task?
Very Little Effort (1) ------- Extraordinary Effort (5)

Means*

Graduate	**3.19**
Undergraduate	**3.46**

		List Gathering Process	
		With List Gathering Tool Support	**Manual**
Voting Process	**With HDV Tool Support**	**3.35**	3.11
	Manual	3.28	**3.40**

*: Only mean values with significant result are presented in the above table.

Source	DF	Sum of Squares	Mean Square	F Value	Pr> F
Model	7	9.80	1.40	2.26	0.03
Error	178	110.10	0.62		
Corrected Total	185	119.90			

Source	DF	Type III SS	Mean Square	F Value	Pr> F
Degree	1	5.09	5.09	8.22	**0.005**
LTool	1	0.002	0.002	0.00	0.95
VTool	1	1.54	1.54	2.48	0.12
Degree*LTool	1	1.93	1.93	3.11	0.08
Degree*VTool	1	0.002	0.002	0.00	0.95
LTool*VTool	1	2.60	2.60	4.20	**0.04**
Degree* LTool*VTool	1	0.35	0.35	0.57	0.45

However, in terms of difficulty of the task, they reported an average of 2.81, which means they didn't think that the task was difficult to them as an individual. This demonstrated that most subjects had underestimated the task.

When they were asked, "to what degree do you think the task was interesting and motivating to you?" with an average of 3.49, they thought that the task was somewhat interesting.

A majority of subjects (91.5%) thought completing the task was important to critical to them. This can be explained because they needed to finish the task to get course credits. They seemed to have enjoyed the task (mean = 3.18) and thought there was enough information (mean = 2.18, from 1 as definitely to 5 as not at all) provided for them to carry out the task. They thought the task description was pretty clear with an average of 3.81.

As to the knowledge necessary for the task, subjects seemed to be very confident in themselves. The average of 3.74 indicated that they thought they have to a great extent the background experience/knowledge that was needed to finish the task. 92% of subjects reported having some extent to a very great extent of background knowledge.

In response to the question "Was there an understandable approach that could be followed in doing your contributions to the task?" 84% of the subjects gave a positive answer.

The task survey shows that subjects were pretty confident in doing the task, and may have underestimated the difficulty of the task. And there was a clear defined approach for them to follow in doing the task.

7.6 System Survey

After subjects completed the experimental task, a system survey (Appendix B.8) was distributed to the subjects in tool support conditions to collect their feedback on the system (list gathering too, voting tool, or SDSS Toolkit). The data was analyzed using NVivo, a qualitative research software package, as discussed in Chapter 6. This section discusses the results from the system survey.

In the system survey, subjects were asked to answer the following open-ended questions:

- Which features do you think are the most useful?
- Which features do you think are the least useful?
- What features should be added to this system?
- What features should be removed from this system?
- What changes would you recommend to make the system easier to use?
- What changes would you recommend to make the system more effective for the task you were given?

Overall, most of the subjects expressed positive opinion toward system features. For example, some subjects commented "the features are all inter-related (systematically) so they all worked very well together." "I liked the idea behind the SDSS toolkit and the root items I thought that made our discussion a lot easier than if it was all in a big list." Most of the comments were similar. The following sections summarized their responses toward the List Gathering Tool and the SDSS Toolkit.

7.6.1 Most Useful Features

The following list summarized comments shared among subjects (only comments on the List Gathering Tool and the list gathering part in the SDSS Toolkit are presented):

1. Presentation
    - The automatic refresh.
    - List summary table
    - Display of the list status
    - Flag saying it was new – "be able to find out what is going on when a new item is posted in the List Gathering Tool"
    - Mark Read and Mark all Read

- View all postings in a continuous list
- The ability to see only root items, only comments, etc.
- The dropdown menus for the various discussions – "The Drop Down Menus, and the fact they are always there no matter what is being uploaded into the other frames in the web page."
- Group member list with last logon and post statistics – "you could actually see who logged in (and) when"
- Creating lists that are topic or subject driven

2. Posting feature
   - Contributing root items
   - Post comments – "If someone wants to make comment on someone's post they (do) not have to reply or have to do another work just hit comment sign and comment will post just under of post so user can't confuse to know this comment belongs to which posting."
   - The preview function
   - The ability to attach documents
   - The ability to edit messages after posting
3. Modification
   - The ability to suggest revision on other's ideas -- "add on to someone else's comment or idea is a useful idea"; "it help us keep the discussion organized"; "it allows groups to decide on the best wording for an idea."
   - The ability to vote on the modification
   - The ability to vote on items and have the tally displayed

- Modifications and comments can be viewed separately and that was also useful in using the system.

4. Comments related

- The ability to separate comments into pro/neutral/con – "I liked the ability to tag the comment as PRO, CON or NEUTRAL...This made it easier for me to vote"(from a subject in a group with only the List Gathering Tool support)

5. Other

- The ability to work on multi-projects and tasks at the same time – "Easier for having multiple discussion topics and decision making items. Each decision making problem can be a separate discussion altogether."

From their comments, subjects showed their preferences toward the ability to determine the amount of information that a user wants to handle (via the selection of show mode: only root items, only comments, modifications, and view all), the ability to work on multiple tasks (different lists) at the same time, the ability to determine a better wording for a proposed item, and the ability to check out group members' status. The above comments reflected all the features that the researchers originally designed. These comments are really encouraging. It seems that subjects did pay attention to those features and tried to make use of it.

7.6.2 Least Useful Features

Similar to responses to the previous question, most subjects expressed very positive opinion when they were asked to list the "least useful features", such as "*It appears that all implemented features are useful*", "*Nothing was un-useful. Everything was useful.*" "*All features were useful to accomplish the task*", "*Personally, I like all feature of system,* *and so I can't say anything about least useful feature.*" "*Every thing was useful to make the system work correctly.*" The list below summarized some features brought up in the comments:

1. Presentation

   - Sizes of the icon – Due to the limited size of the frames, in order to fit all the options in one screen, icons were presented pretty small on the screen. "*I don't see anything as such but would like to say that once you try to separate the tool bar and the screen below it, its really difficult to separate it as the icon is very small and irritates you. Other than this tiny flaw, everything was good.*"
   - Repetition of the information – The information about current location presented twice in the system: one in the navigation bar, the other in the list summary frame. The purpose for this was to give users awareness of where they are. But this seems to be redundant to the subjects. "*Below the select option, there is the name of the topic and list is given. Which is unnecessary as it's already given in the select option*"

2. Modification related

   - Vote on the modification – "The voting process was useful but not efficiently used by the group. Modifications were less understood by the group and everyone relied on comments rather than the voting or modification process."
   - Users' perception on the suggested better wording – "The modifications came least to me because it kind of felt that someone was better than you."

3. Comment

    - The ability to separate different types of comments – "The Pro/Con and Neutral feature - if you put con, it seems so condemning, I would rather put neutral for everything."

In addition to the request of making icons larger, subjects expressed their interest mostly on "modification" and comment features in the system. One reason for those negative comments on the separation of comments and modification seems originated from users' mental model. They worried that such kind of tag to the postings would give other users an offensive signal. These comments will serve as guidelines for the author to improve the system later.

7.6.3 Features that Need to be Added

In addition to extreme positive comments such as "Overall, it was a good system - can't think of anything missing." "There is nothing that needs to be added." "I think the system is fine the way it is." "With current features the system is effective enough to carry out the experimental task properly." a lot of good suggestions were collected. Most subjects focused on the user awareness, group coordination and multiple channels of group communication, which are essential to such an asynchronous collaborative system. Some common suggestions are listed below:

1. User awareness

    - Email notification – since subjects need to at least log in to the system to check the status of the system, they hope that a notification can be sent by email whenever there is a change in their topic. "*E-mail Feature, so that* *group members can just write E-mail to each other if they want to write privately to some member*"

- Allow "paging" or "who is on now" auditing of members

2. Communication channels

   - Meeting room for online meeting
   - Voice so that the team can talk to one another
   - Online chatting

3. Group coordination

   - Group calendar – "To have a calendar, so we can put what tasks need to be done on what day. To have an events section, where we can place latest progress report."

4. Coordinator's privileges

   - The ability for the coordinator to move root items and all supporting posts to another list.
   - The ability for the coordinator to edit all posts.
   - The ability for the coordinator to replace a root with a modification, yet keep the old root as a 'Replaced' object. In other words, keep from losing historical data unless the coordinator decides to delete a post item.

5. Need for voting system

   - Advanced voting system – Subjects in the List Gathering Tool support only condition expressed the needs of a voting system. This is actually what the researchers expected. "The inability to vote based on the comments seems to be a downside. Unless I missed a feature, we were only able to vote on the modifications. It would be nice to have that feature on the comments so that we could utilize that to come up with the rank order." "Vote: we can only vote on the modification, but not the ranking we need to produce." "The system should provide voting on root item as well as the modification."

6. Other

- The ability to CLOSE a root post and all supporting posts so others cannot add to the root.
- Easier text formatting features
- Preference setting – "preferences for where to start (topic/list)"
- Ordering of items/lists – "Allow re-ordering of list sequence (roots especially)"
- Move items/Merge lists – The feature of moving items to another place was available at the time of experiment. However, in order not to overwhelm the subjects with too many "new" features, the researchers did not emphasize it in the tutorial. Therefore, most subjects did not use that feature. "Allow movement of lists so that one can be merged within another"
- History log – All history data was saved in the database. But the researchers need to find a good way to present them to users. "A history log file of actions performed by the team, with the ability to restore an item if accidentally deleted"
- Tutorial – Currently, if users want to see the tutorial (or help), another window will be popped up. Users seem to prefer having tutorial in the same page with the system, so that they can use the feature according to the tutorial

instead of changing the focus on the windows back and forth. "Have the tutorials on the same page as the polls, in a place where you can easily get at them."

- Automatically generate report – This feature was implemented in the previous version of the list-gathering tool. It can reduce the effort of report writing. "System should generate a text file of all the root items, their comments and modifications for a particular list."
- Spell check

7.6.4 Features that Need to be Removed

Not many different comments from this question were obtained. Most common answers to this question were "None", "None. I liked it a lot, and thought it was well laid out." "I think all of them should be intact, as they are useful" "Can't really think of any that bothered me enough to remove them". Some subjects thought that the time period for the experiment was too short that they did not have time to really explore the system. The only feature some subject specified was "Modification" -- "I thought this feature was ineffective for the context of the task. I do not believe I used the feature and I do not think it was heavily utilized by my group members." Giving the fact that they were familiar with the comment structure adopted in most online conferencing systems and the limited time for this experiment, further practice and time are needed for users to adapt to this system.

7.6.5 Changes Recommended to Make the System Easier to Use

Although subjects had positive responses toward tool(s), they also pointed out some features that need to be improved. Common requests on the List Gathering Tool and SDSS Toolkit are presented in the list below:

1. Distinction between modifications and comments – "*It made no sense to have a separate link for modification, because this functionality is already covered under comment.*"
2. The ability to make comment on another comment – "*You could not comment on a comment and therefore could not convey the right message.*"
3. Pro/con labeling of comments – there were no icon identify different comment in the list index. Users can only see different types when they see the detail information.
4. The size of the text – subjects felt that the size of the text displayed in the system was too small.
5. Automatically mark read – subjects suggest to mark an item as read automatically when they read the item.
6. More user-friendly interface – "*While the system was very easy and straightforward to use, it was plain; I think it could have been a little more vibrant to spark creative discussion.*"

This list showed some overlap with the previous most useful list. This suggests that even though certain feature, such as modification, was regarded as very useful, there is still space for improvement. It gives the author hint on why some features were not frequently used, such as the labeling of the comments and modification suggestion. It also shows that it needs to take some time and effort for users to get used to the system.

7.6.6 Changes Recommended to Make the System More Effective

Similar to the answers to previous questions, most comments to the question on changes to make the system more effective for the task were encouraging: "I recommend no changes. It is great, understandable, and user-friendly in my opinion. I had no problems using it." "The current system is fine for the given task." "The way the system is it was effective for me." "I do not feel there is a need to change the system to increase efficiency. Effectiveness of system may be improved by greater involvement and participation of group members."

As expected, most subjects in the List Gathering Tool support only groups expressed the need for a voting tool support – "Ability to vote on comments. I think the voting process should be looked at for potential ways to improve it and make it more effective." The following list summarizes the features subjects specified regarding system improvements to make the system more effective for the task:

1. Group coordination – "*A calendar within the system with what will be next would be very helpful*"
2. Improve the system performance – "*Only to speed up the system, the mechanics are already set up very well, but sometimes when posting a new thread or reply, there were long pauses.*"
3. Add communication channel – "*Instant messaging to let users know that there will be a meeting so everyone will likely participate*", "*Synchronous chat option.*"

4. Member participation – "*I do not feel there is a need to change the system to increase efficiency. Effectiveness of system may be improved by greater involvement and participation of group members.*" "*More active participation*!!"

One of the most interesting points made by subjects was the emphasis on the group member participation. Same as what observed during the experiment, some members of the group did not participate in the group discussion actively. This seems to be a big concern for groups as well.

7.6.7 Summary

Although the comments made by subjects were similar, there was a big variation on one feature – "Modification". Some subjects thought that it is a very good feature. Therefore, they listed it under "most useful features". Some thought that it led to confusion with general comments. Therefore, they present it under "least useful features" and proposed to remove it. And some subjects were in between. They thought that it is a good feature but needs further improvement. Such a big difference between subjects suggests that software designers need to carefully define the feature and present it to users.

The comments gathered from this survey will serve as a guideline for the researchers to improve the system later.

7.7 Discussion

7.7.1 Evaluation of Hypotheses

From the discussion of previous sections, only two significant results partially support two of the hypotheses were found. Table 7.26 presents the summary of each hypotheses and its result.

Table 7.26 Summary of Results

Dependent Variable	Type of Measure	Hypothesis/Research Question	Result
Perceived Quality of Decision-making	Subjective (Post Questionnaire)	H1. Groups supported by tools, compared to groups not supported by tools (manual groups), will have higher perceived quality of decision-making.	Not supported
		H1a. Groups supported by the list gathering tool, compared to groups not supported by the list gathering tool, will have higher perceived quality of decision-making.	Not supported
		H1b. Groups supported by both the list gathering and the voting tools will have the highest perceived quality of decision-making.	Not supported
Process Gain (Level of Understanding)	Subjective (Post Questionnaire)	H2. Groups with tool support, compared to groups without tool support (manual groups), will have a higher level of understanding of the task.	Not supported
		H2a. Groups with the list gathering tool support, compared to groups without the list gathering tool support, will have a higher level of understanding of the task.	Only supported on the analysis on the ability to discover valid alternatives
		H2b. Groups with both the list gathering and the voting tool support will have the highest level of understanding of the task.	Only supported on the analysis on the ability to discover valid alternatives
Process Loss (Information Overload)	Subjective (Post Questionnaire)	H3. Groups with tool support, compared to groups without tool support (manual groups), will have lower levels of information overload.	Not supported
		H3a. Groups with the list gathering tool support, compared to groups without the list gathering tool support, will have lower levels of information overload.	Not supported
		H3b. Groups with both the list gathering and the voting tool support will have the lowest level of information overload.	Not supported

Table 7.26 Summary of Results (Continued)

Dependent Variable	Type of Measure	Hypothesis/Research Question	Result
Solution Satisfaction	Subjective (Post Questionnaire)	H4. Groups with tool support, compared to groups without tool support (manual groups), will be more satisfied with their solutions.	Not supported
		H4a. Groups with the list gathering tool support, compared to groups without the list gathering tool support, will be more satisfied with their solutions.	Only supported for graduate student groups
		H4b. Groups with both the list-gathering and the voting tool support will be the most satisfied with their solutions.	Not supported
Decision Schema Satisfaction	Subjective (Post Questionnaire)	H5. Groups with tool support, compared to groups without tool support (manual groups), will report higher level of satisfaction with their group process.	Not supported
		H5a. Groups with the list gathering tool support, compared to groups without the list gathering tool support, will report higher level of satisfaction with their group process.	Not supported
		H5b. Groups with both the list-gathering and the voting tool support will report the highest level of satisfaction with their group process.	Not supported
Quality of Decision Making	Objective (Expert Judges: Group Report & Criteria Lists)	H6. Groups with tool support, compared to groups without tool support (manual groups), will have higher quality of decision-making.	Report: Not supported Criteria: Not supported (NoVTool > VTool) Subsidiary Result: Graduate > Under
		H6a. Groups with list gathering tool support, compared to groups without list gathering tool support, will have higher quality of decision-making.	Not supported Report: LTool < NoLTool Absolute Criteria: Under NoLTool> All Others Relative Criteria: No significant effect
		H6b. Groups with both list gathering and voting tool support will have the highest quality of decision-making.	Not supported Report: LV < NN Absolute Criteria: No significant effect Relative Criteria: No significant effect

Table 7.26 Summary of Results (Continued)

Dependent Variable	Type of Measure	Hypothesis/Research Question	Result
Total Words of Comments	Objective (Calculated by a computer program)	Research Question: Will the use of this SDSS toolkit affect the length of comments? Will it result in shorter comments while using the List Gathering Tool?	VTool < NoVTool Graduate: List < NoList Coordinator > Member Graduate > Under Coordinator (Most) Under Member (Least) VTool Under (Least) Manual Coordinator (Most)
Equality of participation	Objective (standard deviation of members' percentaged word counts)	Equality of participation	No significant difference
	Subjective (Task Survey)	The effort required to carry out task	Subsidiary result: Under > Graduate No support highest

There was a significant difference in the perception of the ability to discover the valid alternatives between groups supported by the list-gathering tool and groups without the List Gathering Tool support. A significant interaction effect between the List Gathering Tool support and the voting tool support was also found. The tools supported groups tended to agree that the group process uncovered more valid alternatives that the individual had not considered.

As a subsidiary result, the analysis of the effects of the degree program of the subjects indicated that the degree level that the subjects were involved in did play a role in the subjects' perception. For example, the graduate student groups with the List Gathering Tool support had significantly higher satisfaction toward their solution, and undergraduate student groups without tool support reported significantly higher satisfaction toward decision schema. This seems to indicate that graduate students tend to appreciate the tool more. One of the reasons for this result might be that most of the graduate students who participated in the experiment were MSIS students who are likely to have been exposed to the Delphi process through one of their core courses. Therefore, they were more likely to understand the process suggested in the experiment. Another explanation might be that the tools were not very easy to understand. Since most of the students were already very familiar with the WebBoard conferencing system, which they frequently use for their regular courses, their mental models were more likely to accept the organization of that system. The tools used for this experiment were not the same as the one in their mental model; it might take more time for them to adapt to this system.

As discussed in the first section, the subjects' backgrounds were different. Although an effort has been made to randomly assign each subject into different treatment groups, it will be interesting to see whether the subjects' previous working experience has any confounding effect. However, no significant correlation between previous working experience and their response to the post-questionnaire was found.

From the observation of the group process during the experiment, differences in terms of their participation behavior between students from different courses were noticed. For example, most students from a graduate IS core course worked much harder – they spent more time on the system (in terms of times they logged into the system, the items and comments they posted) – while students from a MIS course tended to disappear for several days and then came back at the last minute. But no significant difference was found comparing the means of the responses among students from different courses.

In terms of the quality of decision support, it was found that groups without the List Gathering Tool support had higher quality than groups with the List Gathering Tool support, groups without any tool support had the highest quality in the group report, and graduate student groups had higher quality than undergraduate student groups. Groups in the manual condition had less distraction than groups in tool-supported conditions. Subjects in tool-supported groups needed more time to figure out how to use the system. Moreover, the list generated from the group discussion was not large enough for the effectiveness of the List Gathering Tool to be visible. Subjects in the manual condition were able to comb through the discussion comments to collect the small number of items. However, if there were more items, and more active discussion during the group process (large number of items and comments), it would require huge effort to dig into all the comments and gather all the items in the discussion conference. In this case, List Gathering Tool users may find it easier to obtain the list because all the items have already been well organized into a list.

Graduate student groups as majority in manual condition might have also contributed to the difference in terms of quality of group work under different treatment. Due to the economy down turn during the experimentation period, the number of registered graduate students dramatically decreased. This made it almost impossible for the researchers to get enough subjects from graduate student body in NJIT. Therefore, some undergraduate students were recruited. Because of less working experience of undergraduate students, the difference in the quality of group work between the graduate and undergraduate students was anticipated.

Further analysis comparing graduate students' performance over different time period revealed that the quality of their work declined significantly over time. The current economic situation may be one of the factors here. The pressure of losing current job, or finding another job after being laid off made subjects not able to focus on their course work, not to mention the experiment task. Therefore, performance of tool-supported groups dropped dramatically.

As for the quality of the criteria list, although undergraduate student groups had the highest grade, it is interesting to see that the graduate student groups with the List Gathering Tool support did have a higher average grade than graduate groups without the List Gathering Tool support. It will be interesting to see how it will be after all the subjects are familiar with the tool and work on a real task. This seems to suggest that the List Gathering Tool might be able to play a role in improving the quality of group work. More over, the inter-rater reliability test on the expert judgments turned out that there were big differences between different judges. Therefore, the results on this quality measure were not conclusive.

Although the voting tool supported groups had the shortest comments, the groups with both tools support did have shorter comments overall. Comparing the mean length of comments by all the conditions, groups without any tool support had the longest comments. This seems to show that the tools might have helped groups focus on the task and helped reduce the duplications during the discussion. An analysis on the correlation between the comment length and the decision quality did not reveal any significant relationship.

The result that coordinators had posted significantly more comments than the regular group members can be explained by the extra work done by the coordinators. During the experiment, the coordinators need to coordinate all the work within their groups. For voting tool supported groups, the coordinators need to decide when to vote, request the vote and remind all the members to start a voting session. Therefore, they tended to post more and longer messages than others did. Make the voting and the List Gathering Tool work together might be able to reduce this kind of workload.

7.7.2 Problems Encountered During the Experiment

Even though the researchers did several rounds of pilot study, the author met some new problems during the actual experiment. This section discusses the problems the author encountered during the experiment:

1. **Ethics Issues**

   Since this is an asynchronous experiment, a standard experiment overview letter was sent (Appendix B.1) to the professors and asked them to make it available to the students to recruit subjects. The overview letter stated clearly that all the communications will be online and they will collect the instructions by email and postings in the conferencing system (WebBoard). Students signed a consent form electronically to indicate that they were willing to participate in the experiment. In order to make sure that all the subjects finished the task on time, email was used to remind them of the deadline. Unfortunately, one of the subjects thought the researchers were using emails to *harass* him/her.

   At the beginning of the experiment, subjects were requested to introduce themselves and try to elect one coordinator for their group. If they failed to choose a coordinator for their group, the researchers would randomly assign one for them. After the deadline for this activity, the researchers posted a message in the conferencing system confirming the name of the coordinator. But one of the subjects who was nominated by group members didn't want to accept the position. He sent the researchers the following email:

> *I did not volunteer. How can you let someone volunteer me? I suggest that you make the person, ..., who volunteered me, be coordinator. How would you feel if this was done to you? It's not the extra effort, it is the method in which I was railroaded into this that bothers me. Is this in line with NJIT view of ethical behavior?*
>
> ……
>
> *I don't want to be Group Leader because of the underhanded way that I was 'elected'.* ……
>
> *One student singled me out and the other two chimed in to ensure that they wouldn't have the extra work.*

He then sent out several other emails to other group members indicating that he didn't want to be the coordinator. Since he had spread negative feelings about the experiment, the researchers had to rearrange him to another group to continue the experiment.

Ethical issues are always one of the most important issues when conducting this kind of research. At the beginning, the researchers didn't realize that the above problem was an ethical issue because the researchers thought they had stated very clearly that the coordinator would be assigned randomly in case the group didn't have one by the deadline. After discussing with advisors, the researchers realized that they could not force any subject to be the coordinator. This kind of issue should be considered while conducting the experiment.

2. Lack of Active Participation

As in some other experiments that use students as subjects, the researchers gave subjects course credits to encourage them to participate in the experiment. There was an alternative task for the students if they did not want to participate in the experiment. Although the researchers explained that the effort required for both the experiment and the alternative task were almost the same, most students expected to put less effort into the experiment. Bear this in mind; some students didn't participate in the group discussion actively. They didn't want to put much effort into this experiment. Some of the students just posted one or two items in the group working area at the beginning of the experiment and thought that they had finished the task. Instead of following the instruction that requires everyday activity on the system, some students thought that the task only required one time contribution. For instance, one of the subjects posted one comment on the system and said "I think we have done"; one of the subjects didn't have any activity after logging onto the experimental system, he was thought to have dropped out from the experiment. However, during the last night of the experiment, he posted 46 comments onto the system. Most of his comments were simply "Yes, I agree" or "No".

This problem was more serious in groups that participated in the experiment in Fall 2002. A time wise correlation between groups that carried out the experimental task in Spring 2002 and Fall 2002 revealed a significant drop in terms of group report quality. Although there is not enough data to fully explain the course of this decreased performance, the researcher feel that many students were facing problems about maintaining jobs or finding jobs in the economic downturn might have contributed to it.

During the experiment, email reminders for the upcoming deadlines were also sent to subjects. However, not many telephone calls were made to those who didn't complete the task due to the fact that it may introduce bias to the experiment.

3. Mortality (Drop outs)

There was high mortality (about 30% drop out rate) during this experiment. There was a set of pre-defined procedures for this experiment. Subjects needed to finish each step within a certain time period before they could continue the experiment. The researchers had to drop some subjects because they didn't finish the task on time. Some subjects simply didn't participate in the group discussion. Since the experiment started before the last day to withdraw from a course, students who withdrew from the course didn't complete the experiment.

In order to reduce the mortality, emails were sent to subjects one day before the deadline to remind them about the experimental schedule. Since some steps were only two days apart, subjects might have been overwhelmed by the emails. This might be one of the reasons why one of the subjects complained about getting emails as discussed in the ethics issues section.

4. Training

In order to prepare subjects for the experimental system and task, a standard training website was developed for each condition. It includes a set of mini-lessons on how to use the corresponding software system and a set of training tasks for them to exercise. Success in completing the training tasks indicated that they have learned basic features in the system which should be used for carrying out the experimental task.

Most subjects finished all the training tasks within the preset deadline. Unfortunately, they underestimated the difficulty of the system and the task. Since most of the subjects did have extensive experience in using the computer systems, they tended not to go through the tutorial step by step. Instead, they used the trial and error method to finish the training tasks. Moreover, they didn't regard the training task as a warm up for doing the real experiment task. They simply wanted to finish it and get over with it. That leads to the fact that some of the subjects didn't really know the system before they started the experimental task.

Comments from the system survey also indicated that subjects didn't realize the importance of the training. Even though they finished the tasks, they still did not know how to use various features to help them in the experimental task. This can be one of the reasons why the results from the groups supported by the tools were not better than the results from the groups without support.

Another problem was that the training task was designed as several separate exercises of using the system. Subjects didn't know to what level they needed to master the system for the experimental task, and in which ways they could use the system. In this case, a training task that is similar to the experimental task might be more appropriate for training purposes.

5. Mix with Other Experiments

Because there were several similar experiments carried out at NJIT during the same time period, some subjects might have participated in the different experiments through different courses. All the experiments used WebBoard as one of the communication systems, the training for using the WebBoard and the training tasks were similar. This caused some confusion among subjects. For example, after emails were sent to subjects reminding them to finish the training tasks, one of the subjects replied, "I have finished all the training tasks on 'Fire'." Fortunately, this experiment was carried out using another server. And the researchers identified this problem easily.

In this situation, different time periods might be used for different experiments in one organization. Or the number of similar experiments one can participate should be limited at the same time.

6. Time

From the task survey, some subjects expressed that they would like to have more time to carry out the experimental task. The experiment lasted about three weeks, in which ten days were used for group discussion and report writing. According to the experimental procedure, subjects needed to propose all the items they could think of and organize them into a list, then vote on the list; based on the voting result, they could modify the list and discuss again until they reached a group decision. They should be able to do several rounds of discussion and voting to finalize the group decision. Nevertheless, most groups only had time to vote on the list once. One of the reasons for this was that group members always deem voting as the last step of the group discussion. They tended to put the voting session off to the last day of the experiment, just as a required step in the experiment procedure. Moreover, due to the nature of asynchronous communication, delay was expected during the group discussion and voting process. For those groups which tried several rounds of voting, often times, there were only one or two people who voted before the voting deadline was passed. In this case, they had to restart a new voting session to let other group members vote.

More time and more training on the concept of the system might be needed in this case. However, the mortality might have been even greater if the experimental period were longer. Doing a field trial of the system, which uses the system to do a real world task, might be a solution to this dilemma.

7. System Performance

From the system survey, some of the subjects reported that the system was slow when there were many items in the list, and the idea of suggesting and voting on the modification caused confusion. Subjects also complained that the system should provide a mechanism that allows comments and replies. This was due to the fact that subjects were very familiar with the conferencing system. As a matter of fact, this system was not designed as a conferencing system. Ideally, the List Gathering Tool should be used within another conferencing system to help group members better organize their ideas. But in order to get control to ask the subjects to use the system, and try to force them to focus on the task, the researchers didn't let subjects use any other communication system to do the discussion.

Since some subjects had already become used to the conferencing system, they had difficulty in adapting the new system and focusing on the task in such a short time period. This might have hindered their performance on the task. A field trial for a longer time period might help in this respect.

The system also needs some more improvements in terms of user interface and features it implemented. For example, after the modification on a certain root item has been made, all the comments on the previous items are still there. Although the modification history of the root item was recorded in the database, it was not displayed to the user. This may cause some confusion when one user reads a comment which refers to the previous wording. This history information should be made available to users for their reference.

8. Quality Evaluation and the Use of Judges

In order to get an objective measure of quality of group work, two sets of expert judges were used. One set of six judges were used to determine the quality of group reports, another set of four judges were used to determine the quality of individual items proposed by groups.

Even though there was a half-day training for judges who graded group reports, some normalization of the evaluations among judges had to be carried out to obtain reasonable consistency.

While all four judges who graded on the items were people who supposedly had been involved in writing the sort of RFP, which is similar to the requirement in the experimental task, for their organization, there were no sufficient correlations of their ratings of individual items to allow their evaluations to be considered as reliable.

9. Condition Assignment

While the researchers tried to assign subjects into different treatment groups, they did not really achieve the randomization. In Spring 2002, since the software was not ready for the experiment yet, the researchers had to arrange all the graduate students who volunteered to participate in the experiment to manual condition (the WebBoard only) for that term. The decreasing situation with respect to jobs and the possible problem with motivation was not present in the initial groups.

When the researchers did the experiment in Fall 2002, they had problem getting enough subjects from graduate division, and had to recruit subjects from undergraduate division. This forced the researchers to use more undergraduate student groups in tool-supported condition. The comparison between graduate and undergraduate groups showed significant difference in terms of the quality of their group reports. Graduate groups did significantly better than undergraduates. The uneven number of groups in each condition made it difficult to explain the differences among conditions.

7.8 Summary

This chapter discussed data analysis, the results of this experiment, some problems encountered during the experiment, and some possible solutions.

Based on the experimental data, most of the hypotheses were not supported. There were several possible explanations for this lack of support. First, the subjects were lack of motivation to carry out the task and the overall participation was poor. Second, the task and the procedures were complex and the subjects underestimated the task. Therefore, they didn't put enough effort into it. It was obvious that some of the subjects simply didn't do the work. Third, with the complexity of the tool(s), the training was relatively inadequate. Due to the fact that most subjects had been using WebBoard for their course work, they were also very familiar with the software before the experiment started. However, subjects in tool-supported conditions were not able to get familiar with the tool(s) in such a short period of time. Fifth, due to the bad timing and limited time period, the subjects encountered several conflicts with other experiments, mid-tem exams, or course withdraw. Therefore, many subjects were not able to focus on the experiment. Sixth, the conditions were not evenly assigned due to the change of student body. Most importantly, the number of items contributed by the subjects in each group was rather small, which made it easier for subjects in manual condition to manually collect all the items from their comments. Thus, the benefit of the List Gathering Tool or the SDSS Toolkit was not so obvious.

Although not all the results of the experiment were what the researchers expected, it does prove that the List Gathering Tool and the combined SDSS Toolkit do tend to improve the ability to discover valid alternatives. There were some significant results comparing graduate students to undergraduates (i.e., the newly introduced controlled variable). This seems to indicate that students with more experience tend to accept this kind of system more quickly. In a real organization setting, a group of experts who want to solve some really complex issues might be able to benefit from this kind of system if they used it frequently or over a period of time longer than ten days.

CHAPTER 8

FIELD STUDIES[1]

Several case studies of the use of the Web-based collaborative Social Decision Support System (SDSS) Toolkit (the List Gathering Tool combined with the Dynamic Voting Tool) have been conducted since the implementation of this toolkit. Although field studies were not formally proposed in the proposal, they were carried out since the author and her colleague, Zheng Li, believe that observing the use of the toolkit in a real setting will give the researchers a better idea of how the toolkit can be used to help people solving real problems and its possible applications. Zheng Li and Yuanqiong Wang jointly conducted the field studies and have reported these cases in their paper published in Americas Conference on Information Systems (Wang, et al., 2003). This chapter summarizes three case studies of use of the toolkit by students in graduate level courses at New Jersey Institute of Technology (NJIT) to assess what they had learned together. The students were asked to collectively pool their interpretations of what they learned and see to what degree they had a consensus on the importance of topics covered in the course. The evaluation process and results are presented in this chapter as a case study on how such a toolkit can be used in a collaborative learning environment. In the conclusion, possible enhancements and the future use of the toolkit as a learning tool are discussed.

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[1] Portions of this chapter came from "Using a Social Decision Support System Toolkit to access achieved course objectives," Yuanqiong Wang, Zheng Li, Murray Turoff, Starr Roxanne Hiltz, Proceedings of the 2003 Americas Conference on Information Systems, Tampa, FL, 2003.

8.1 Introduction

Collaboration among students in online courses as well as face-to-face courses enriches the learning experience, enhances the exchange of knowledge, and transforms a potentially solitary existence into an interactive journey (Benbunan-Fich, 2002; Hiltz, 1994; Lazarus, 2002; Leidner and Jarvenpaa, 1995). A useful collaborative learning tool will allow a class to engage in a structured discussion on a particular issue (Clark, 2000; Harasim et al., 1995; Turoff et al., 1995). Furthermore, a Web-based system gives great flexibility for both in-class teaching and distance learning.

Evaluating whether the teaching objectives have been met at the end of the course can help the instructors to improve their teaching, and help the students to review the course material, hence further understand the course subject. Such an end-of-course exercise is itself a form of computer-mediated collaborative learning (Alavi, 1994). Most course evaluations have been focused on the instructor's teaching behaviors, such as being an organized presenter of information or being fair-minded in grading, and the students' performance. And often times, the evaluation of the instructor's ability was based on a standard student survey questionnaire, either paper-based (Achtemeier, et al. 2003; Hmieleski, 2000; Hmieleski, et al. 2000) or online survey, while the evaluation on the students' perceptions was based on a final exam at the end of the semester. However, very few prior studies were found that compared the teaching objectives and students' perceptions of the course contents. According to Brown and his colleagues (1989), the gap between the client experiences and professional perceptions of client experiences will highly influence clients' evaluation of the service. Therefore, finding the gap between students' perceptions and instructors' teaching objectives can help teaching staff to improve their teaching.

Since Spring 2002, the SDSS Toolkit has been used to evaluate what students learned from several graduate level courses, including three face-to-face sections and three online sections, at NJIT. These exercises were trials for the researchers to examine whether the students' perceptions of the course are the same as the course objectives designed by the instructor. It can also show if a large distributed group could use this sort of software asynchronously to efficiently agree on a list of items, including multiple rewordings as a large group contributed to the quality of the resulting list, and a preference rating for the items on the list that represented the collective intelligence of the group.

8.2 Course Background

NJIT has been employing group communication software to deliver distance-learning courses and to enhance face-to-face classes since the early 1980's. Currently, most graduate level courses in the Information Systems Department are delivered through face-to-face lectures combined with online activities. Students registered in a face-to-face section are encouraged to use a computer conferencing system to further discuss the course topics, in addition to listening to the lectures in class. Most of the courses are also offered online, combining lectures on CD ROM with discussions and collaborative assignments in the same conferencing system.

Three graduate level courses in the Information Systems Department at NJIT--Management of Information Systems (CIS 679), Evaluation of Information System (CIS 675), and Design of Interactive Systems (CIS 732) -- were utilized in these case studies.

As a pilot study for this exercise, in spring 2002, students from CIS 679 used the SDSS Toolkit to come up with a rank ordered list of the most important things they had learned from the course. This course, offered by Murray Turoff, is an elective taken by graduate students in the Master's program in IS and in some other programs, including Computer Science and Management. It is also required for the Ph.D. students in IS. About half the course focuses on the task of managing software development projects for applications in an organization (Turoff et al., 2000). There was one section of face-to-face students and one section of a distance version both utilizing a conference system (WebBoard) as a merged class.

In Fall 2002, students from two sections of CIS 675 and two sections of CIS 732 participated in the same exercise. CIS 675, offered by Starr Roxanne Hiltz and Yuanqiong Wang, is required for all graduate students in IS. The course focuses on how to use both quantitative and qualitative methods to evaluate an information system from the users' points of view. One section was delivered face-to-face combined with online activity, and another was delivered online. CIS 732, offered by Murray Turoff, is an elective for all the graduate students in IS and Computer Science. The course focuses on the design of interactive systems and human computer interfaces. There was also one face-to-face section and one section of a distance version both utilizing a conference system (WebBoard) as a discussion medium.

A summary of the courses which were included in this case study is shown in Table 8.1 below and includes the total students in each class and the number who participated in the post-course evaluation exercise reported here.

Table 8.1 Courses in the Case Study

Course Section	Delivery Mode	No. of Students	Time
Management of Information Systems (CIS 679- 101 and 851)	Face-to-Face + Online activities + Distance section	38 (28 participated)	Spring 2002
Design of Interactive Systems (CIS 732- 101 and 851)	Face-to-Face + Online activities + Distance section	23 (16 participated)	Fall 2002
Evaluation of Information Systems (CIS 675-101)	Face-to-Face + Online activities	27 (15 participated)	Fall 2002
Evaluation of Information Systems (CIS 675-851)	Online only	27 (20 participated)	Fall 2002

8.3 Web-based SDSS Toolkit

The Web-based SDSS Toolkit includes two parts: a List Gathering Tool and a Dynamic Voting Tool, as described in chapter 4. Unlike most online "voting" systems, the Web-based SDSS toolkit allows participants to actually collaboratively formulate the statements to be voted on in a well-designed structured way.

As Turoff et al. (1996) suggested, the heart of a group decision process such as the Delphi process, brainstorming, or Nominal Group Technique (Blanning, and Reinig, 2002; Dennis, Valacich, and Nunamaker, 1991), is the structure that relates all the contributions made by the individuals in the group and which produces a group view or perspective. In a computer-based Delphi, the structure is one that reflects continuous operation and contributions. The List Gathering Tool tries to help a group of users to collaboratively pull their ideas together, and provides a structure to organize those ideas into a list. Using this tool, users can propose their original ideas as root items in a list.

During the discussion period, other users can make comments on the root items, and they can suggest better wording for the root items posted by other group members. After better wording is suggested, all group members can vote on it to decide whether the original item should be replaced by the modification suggested. When a certain pre-determined threshold (e.g. more than 50% of group members voted "yes" to the modification) has been reached, or if the group manager decides to do the replacement (depending on the system setting), the original root item will be replaced by the modification.

When the group members feel that they have reached a point of apparent agreement on wording, or a certain timeline is met, a voting session is made available by using the Voting Tool. Note that in the current version used for this study, consolidation of items could be suggested via suggestions to modify an item, but there is no explicit method to combine two or more items into one. In the results, a number of places where some of the items overlapped were found. This has led to the following revision: participants will also be allowed to propose the deletion of a contributed item. This too will trigger the same yes/no voting process where a majority of all the active participants voting yes can cause the item to be deleted.

As with the proposal to substitute a better wording the original author can accept the suggested change anytime before a majority vote is obtained. It is also possible for the monitor of the process to perform the same function. However, the objective is to encourage the group to operate without the need of human facilitation intervention.

8.4 Evaluation Procedure

At the end of the semester, the course evaluation exercise was distributed as an optional assignment for the students who took the course. The whole process lasted two weeks. It has two phases. First, the students used the SDSS Toolkit to collectively generate their ideas in the form of a list of what they had learned from the course. And then they used rank order voting to see to what degree they had a consensus on the importance to them of the topics or skills. Students who participated in all the phases of this exercise could earn three extra credit points. A total of 115 students from the three courses (CIS 679, CIS 675, and CIS 732) did the exercise.

Phase One: Using the List Gathering Tool to List Items

In this case study, the researchers created a topic for students in each course, e.g. topic “CIS 679 Exercise” for CIS 679. Under the topic, one list called “Things learned” was created as the workspace for students to do the exercise. The students were asked to suggest a concise statement of what they felt was the single most important thing they learned in the course. If someone else had already entered it, then the student needed to come up with something next in importance that no one had previously entered.

If students wanted to present a rationale on why they thought their item was important they could put in a separate comment to the root item to state their justification and where it occurred in the material of the course. The students were free to comment on any root item in the list and that comment could be classified as "Pro", "Con", or just an impartial "Neutral" comment.

The students could propose what they thought was a better wording of the root item which is called a "modification". If more than half of the class voted “Yes” to the modification it automatically replaced the original.

Figure 8.1 illustrates the interface and the process through which students contributed their ideas about what they had learned from the course. The left frame is the index to what may be viewed in the right frame. The controls and menus are in the frame area across the top. The system allows for the collection of multiple lists within a single exercise.

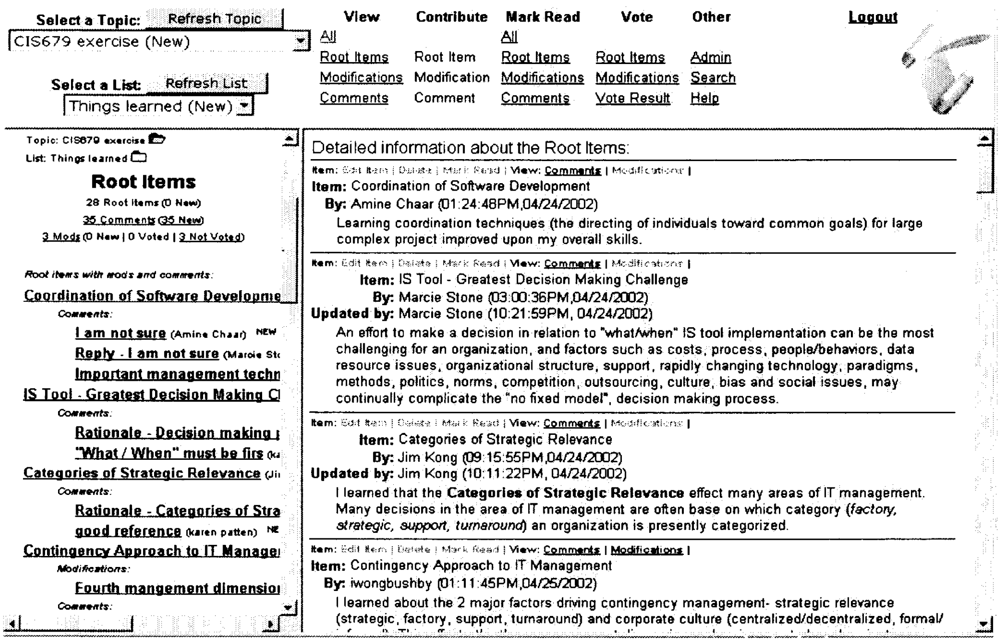

Figure 8.1 List Gathering Tool.

Phase Two: Using the Voting Tool to Vote on the List Items

Once the class seemed to have most of the ideas in place and all the modifications voted on, a rank order voting procedure was triggered for all the items on the list. Students input ranks for the items based on their importance. As the result, the system calculated all the votes and established a rank ordered list of items for the class as a whole.

8.5 Evaluation Results

Table 8.2 shows the summary of the results of the exercise in each course. Figure 8.2 shows the final list of items for each course, in the form of the "top ten things learned." For example, as the result of the exercise, the students in CIS 679 produced 28 root items, 3 modifications (Mods), and 35 comments. In total, 24 students voted on the 28 root items using rank order voting. The items were listed in rank order as determined by an algorithm using Thurstone's law (Thurstone, 1927; Li et al., 2000) which results in a single group scale providing meaningful interval measures of differences in preference. Two items for which half the group preferred A to B and half preferred B to A would occur at the same point on the scale. The top ten list items ranked by the students in CIS 679 were (as shown in Figure 8.2a):

Data Display: | Data Table | Bar Chart | HorizontalBar | Line | Pie Chart | Raw Data | View Comments

List Name: Things learned from CIS679 (Round 1)
Voting Method: Rank Order Voting
Voting Period: ***06/May/2002*** **to** ***25/May/2002***

Display Voting Result
Count only the last vote if a voter voted multiple times

Data Table: Thurstone's Law Result

Data Calculation: | Thurstone's Law | Borda Count | Condorcet | Mean

Distributions of Votes

Rank Order	Item (Discription)	Thurstone's Law	Dis. Above	Dis. Below	25% point	50% point	75% point	Total Votes	Vote Change
1	Runaway Projects	16.50	0	9.72	6.76	4.50	4.11	24	2
2	Categories of Strategic Relevance	6.78	9.72	0.02	6.65	4.11	2.09	24	2
3	Coordination of Software Development	6.76	0.02	0.11	6.65	4.18	2.10	24	2
4	IS Tool - Greatest Decision Making Challenge	6.65	0.11	0.51	6.14	4.11	2.10	24	2
5	Significance of 'people' issues	6.14	0.51	0.96	4.26	3.04	2.76	24	2
6	Risk management during the life of a project	5.18	0.96	0.68	5.18	3.92	2.42	24	2
7	Project management	4.50	0.68	0.24	4.26	3.48	2.27	24	2
8	Managements trade offs	4.26	0.24	0.08	5.18	2.53	2.27	24	2
9	Managing Change	4.18	0.08	0.07	6.65	3.04	2.27	24	2
10	Contingency Approach to IT Management	4.11	0.07	0.19	6.65	3.92	1.89	24	2

Figure 8.2a Voting result (partial) for CIS 679.

Data Display: | Data Table | Bar Chart | Horizontal Bar | Line | Pie Chart | Raw Data | View Comments My History

List Name: Things learned (Round 1)
Voting Method: Rank Order voting
Voting Period: 05/Dec/2002 to 11/Feb/2003

Display Voting Result
Count only the last vote if a voter voted multiple times

Data Table: Thurstone's Law Result

Data Calculation: | Thurstone's Law | Borda Count | Condorcet | Mean Distributions of Votes

Rank Order	Item (Description)	Thurstone's Law	Dis. Above	Dis. Below	25% point	50% point	75% point	Total Votes	Vote Change
1	How to conduct Experimental research?	32.96	0	12.19	20.77	10.58	9.57	29	18
2	Practicality of Protocol Analysis	20.77	12.19	1.31	12.39	9.24	7.57	29	17
3	Statistical Methodology for evaluating significance	19.46	1.31	2.86	16.48	9.57	7.25	29	18
4	Essential ordered Steps in Conducting an Experiment	16.60	2.86	0.12	12.39	8.67	7.57	29	18
5	Protocol Analysis - Learning the cognition process	16.48	0.12	4.09	16.48	9.57	6.08	29	18
6	Survey Methodology	12.39	4.09	0	12.39	9.24	4.02	29	18
6	Methodology of Questionnaire Construction for IS surveys	12.39	0	1.72	10.67	9.24	6.97	29	18
8	Understanding Qualitative Methods	10.67	1.72	0.09	10.58	7.25	5.96	29	18
9	Experimental methods applied in IS study	10.58	0.09	0.51	16.60	8.67	4.84	29	18
10	Evaluation of Information Systems is a Formal Scientific Process	10.07	0.51	0.5	10.67	7.25	4.84	29	17

Figure 8.2b Voting result (partial) for CIS 675.

Data Display: | Data Table | Bar Chart | Horizontal Bar | Line | Pie Chart | Raw Data | View Comments My History

List Name: Things learned (Round 1)
Voting Method: Rank Order voting
Voting Period: 06/Dec/2002 to 11/Feb/2003

Display Voting Result
Count only the last vote if a voter voted multiple times

Data Table: Thurstone's Law Result

Data Calculation: | Thurstone's Law | Borda Count | Condorcet | Mean Distributions of Votes

Rank Order	Item (Description)	Thurstone's Law	Dis. Above	Dis. Below	25% point	50% point	75% point	Total Votes	Vote Change
1	know your users	9.30	0	0.44	9.30	6.93	5.12	13	3
2	Least effort	8.86	0.44	1.93	8.86	6.93	4.10	13	3
3	The Metaphor : Analysis and Selection	6.93	1.93	1.78	9.30	5.15	4.10	13	3
4	Interfaces, mental models and implementation models	5.15	1.78	0.03	6.93	5.12	1.75	13	3
5	Trade off	5.12	0.03	1.02	8.86	5.12	2.37	13	3
6	too much focus on consistency means not enough focus on users and their tasks	4.10	1.02	1.5	6.93	5.15	1.75	13	3
7	Using psychology to enhance interface design	2.60	1.5	0.23	5.15	2.37	1.75	13	3
8	Simplicity and usability in user interfaces	2.37	0.23	0.53	5.12	2.60	1.84	13	3
9	Design of a Web-based Interactive System	1.84	0.53	0.09	5.15	2.60	1.17	13	3
10	Usefulness	1.75	0.09	0.58	5.15	2.37	1.17	13	3

Figure 8.2c Voting result (partial) for CIS 732.

Table 8.2 Results Summary

Course	No. Students Participating	No. Root	No. Mods	No. Comments	No. Votes
CIS 679	28	28	3	35	24
CIS 675	35	42	3	60	29
CIS 732	16	15	5	46	13

With the Dynamic Voting Tool, one can visualize the relative comparison of alternative results on the same data set, which may present opposing different views of the group results. For example, rank order results can be calculated by different methods, such as Thurstone's Law, Borda Count, Cordorcet's Law, mean/average, distributions of votes in terms of the ranks, or simply the raw data (i.e. individual votes). One can choose to display the data in a data table or graphically (e.g. bar chart, horizontal bar, line, or pie chart).

In Figure 7.2a, Figure 7.2b and Figure 7.2c, Thurstone's Law results are displayed in a data table. Thurstone's Law is a data analysis method used for both rank order or paired comparison data (Thurstone, 1927; Li et al., 2001). It has the very unique feature of being able to transform a set of individual rank order data or comparative preference data to a single composite group interval scale result. Therefore, one can identify not only the rank order of the group result, but the meaningful distances between list items.

The rank ordered list from each course showed the perceived class achievements of the students. The instructors used these results to check whether the items proposed by the students match the original course objective in the instructors' mind.

8.6 Feedback from Instructors

Since the author and her colleagues were also the instructors who participated in this case study, this section represents their attempt to take on the role of a "user" of the system.

The lead instructor for CIS 675, Roxanne Hiltz, felt that the top items represented the most important topics in the course, but only if several of the items were combined. For example, questionnaire construction and sample survey methodology were covered in two separate items tied for rank 6, and also mentioned in an item ranked as number 21; if they had been combined, the combined ranking might have been higher. The qualitative methods taught, including protocol analysis or the "thinking out loud" method, were described in separate list items ranked as numbers 2, 5, 8, 24 and 26. A real "surprise" was the very low ranking of the importance of learning how to understand published research articles in information systems. This skill was listed in the course objectives in the syllabus as one of the "top five" but was listed and ranked only as number 41 out of 42 by the students. Apparently they do not value the ability to read and understand journal research articles in Information Systems as much as the instructor does. Alternatively, it may be that the students felt the prior course “Principles of Information Systems” (CIS 677) had covered that topic to a point where they did not need added skill in this area except for the understanding of professional evaluation studies.

For CIS 679, the students contributed all the items the professor expected during phase one. However, the final rank ordered list was a surprise to the professor. For example, not only was “Runaway Project” ranked No.1, but also its Thurstone’s Law results were about two times higher than the No.2 item. A runaway project is one for which the cost is at least twice as much as originally planned. Upon reading the comments made on the item it was observed that this topic became an organization factor or metaphor around which the students associated much of the lecture material dealing with the problems of the development process. So even though only two lecture hours was spent upon this topic as an introduction to the development process, it provided a cognitive framework for the organization of an additional 15 hours of lecture. This was a total surprise to the professor. It was also noted that items 7 to 10 had considerable overlap and many similarities. However, the fact that the scale values are all very close to one another is an expression of this similarity of the items which is a natural result of the Thurstone's scaling process. If an equal number rank A higher than B to those who rank B higher than A, the two items would have the same scale value.

In CIS 732 the top ten items are more equally distributed along the range of the scale values and the items are more distinct and dissimilar in nature. This was a more likely result from a smaller class where each member was asked to contribute only one item. In the future the proposed change to allow deletions should help to minimize the occurrence of overlapping items through the combination of the deletion and replacement process to allow minimization of duplication for the group results.

The important finding from this application of the technology is that instructors may well discover insights about the course they are teaching that are not easy to otherwise determine. It also appears to be very beneficial to the students as is evident in the comments on the proposed items which get to be very interesting insights into the ways the students assess what they have learned.

8.7 Summary and Discussion

These class exercises gave the researchers an opportunity to explore the use of the SDSS Toolkit in an asynchronous distributed learning environment. It shows how the new SDSS Toolkit can be utilized to enhance learning for both face-to-face and distance learning classes. Assessing the achieved course objectives helps not only the students to review what they have learned, but also the instructors, to improve their future teaching. The exercise turned out to be very successful.

However, the results also indicate the need for an explicit process to combine or consolidate initially separate items on the list. In keeping with the spirit of making each operation very straightforward and simple, it was felt that adding the deletion proposal to the rewording proposal and having them each work exactly the same way would keep the tool very easy to use. The design of this asynchronous communication process for large groups is in the spirit of an online "Roberts-rules-order." The fact that each member may address any motion or proposal at any time is the key to allowing asynchronous operation for large groups. How participants voted is not identified and comments may be entered anonymously so that the system can support a complete Delphi process (Linstone and Turoff, 1975). The Delphi method may be utilized as a learning tool for collaborative class exercises.

For this kind of exercise, with the addition of a consolidation mechanism, multiple rounds of discussion and voting will help students to arrive at a final list of items with few duplications. Due to the time constraints of the case studies reported here which occurred during the last two weeks of the course, only one round of discussion and voting can be conducted.

This system can also be used by all the students in a class to continuously explore pragmatic issues in a particular course such as tradeoffs in the design of an information system or an interface. For any course with pragmatic content, this would be an interesting way to have the students collectively pool their interpretations of what they are learning and see to what degree they have a consensus on pragmatic issues in the course. Many instructors have expressed interests in utilizing this toolkit in their teaching, and several courses are using the toolkit as a class exercise now. The researchers intend to place this software in the public domain before the end of 2003.

CHAPTER 9

CONCLUSIONS AND FUTURE DIRECTIONS

9.1 Conclusions

This dissertation has presented the design of a collaborative List Gathering Tool in a web-based environment and evaluation of this tool using various research methods, such as protocol analysis, controlled experiment, and several field studies.

The protocol analysis helped the author identify several "blind spots" that could not be discovered otherwise. The following improvements were made to the interface based on the protocol analysis:

- Typos on the screen were corrected.
- Different kinds of postings were color-coded – light blue for root items, light red for modifications, and light gray for comments; Using color code can help users to identify different kind of postings. Use light red for modification to draw users' interest so that they can take immediate action.
- Automatically refresh screen – whenever a new topic/list/item is posted/deleted, the screen refreshes automatically.
- Use pull down list to display all available topics and lists instead of big box to save space.

After the improvement of the tool based on the feedback from the protocol analysis, a controlled experiment and several field studies were carried out to test the effects of the tool in a group decision-making process.

Although results of the controlled experiment showed that groups with the List Gathering Tool support had higher ability to discover valid alternatives; groups with both the List Gathering Tool and the voting tool (SDSS Toolkit support condition) reported having the highest ability to discover valid alternatives; and as a subsidiary result, graduate student groups did significantly better than undergraduate groups, it also showed some unexpected results. For example, groups supported by both the List Gathering Tool and the voting tool (SDSS Toolkit) did have slightly higher quality in their group work than groups with only one of the tool supports, but it did not outperform groups without any tool support. However, encouraging results from the field studies were obtained – students gathered all the items as instructors had hoped and rank-ordered them. Why is there such a dramatic change between the results of the experiment and that of field studies?

In order to answer the above question, a look at differences between the two types of study is needed. Table 9.1 at the end of this section shows the comparison between the above two types of study.

In comparing the field studies to the experiments, instead of *creating* the case(s) studied, cases in the field studies are constructed out of naturally occurring social situations (Yin, 1994). In this research, although the task was created for using the toolkit, it was closely related to the course subject, and was designed as one of the class assignments. From this perspective, students' motivation was quite different from the one in the experiment. The task used in the field study helped students to review the course subject before the end of the semester. Students were highly motivated to see whether there is any difference in terms of their perceptions on the course among them. They were eager to know whether they had missed any important material covered in the course before taking the exam. However, in the controlled experiment, although the researchers announced that the workload for both the experiment and the alternative assignment were almost the same, students regarded the experimental task as just one way to avoid the heavy load of their alternative assignment. They did not want to spend time on learning and using the tool. They did not want to spend time on the experimental task either. The only thing they cared about was to put together a group report and complete the experiment.

Although there was no formal training for students in the field studies, most students participated in the experiment in the middle of the semester. Therefore, most students who participated in the field studies already had experience using the SDSS Toolkit, or at least part of it (List Gathering Tool or Voting Tool). The more time they spent on the tool, the more likely they were to adapt to the system. After finishing the exercise for the course, some of the students compared their experiences with the system between the experiment and the field study exercise; they felt that as time went by, they started to understand and enjoyed some of features that they did not like previously. This also illustrated the need for more time and practice for users to adapt to the system. If there were a longer time for the experiment, the researchers might have obtained different results.

Comparing the group sizes, the number of students participated in each field study ranged from 16 to 28, while the number of subjects in each group in the experiment ranged from five to seven. Therefore, the complexity of communication involved in the field studies was much higher than it was in the experiment. With the active participation, the students in the field studies created much larger lists than those in the experiment. The success of the field trials suggests that the SDSS Toolkit tends to work well for larger groups (i.e., more than ten people per group) working on more complex practical problems that involve considerable number of items (ideas), comments and modifications.

Despite the unreliability of the expert judgments in the experiment, the motivation, task reality and complexity, subject body, group size, and length of time a user spent on the system contributed to the different results of the experiment and field studies. Overall, the evaluation results are encouraging. It proves that the utilization of the List Gathering Tool or the SDSS Toolkit does improve the ability to discover valid alternatives. And it also implies that if there is enough time to practice, the system can be used for large groups of users, who have necessary experience in the subject matter, to solve complex problems in a real setting. The system works very well when the group is motivated and this was certainly evident in the field trials. Motivation has always been a key element in success in group processes.

Table 9.1 Study Comparisons

	Experiment	**Field Studies**
Type	Quantitative	Qualitative
Subjects	Graduate & Undergraduate students in various majors (including IS, MIS, CS, etc.)	IS graduate students
Course Sections	• CIS 350-101,103 and 451 (Face-to-Face and DL sections) – Computers and Society • CIS 465-101 (one Face-to-Face section) – Advanced Information Systems • CIS 602 (one Face-to-Face section) – JAVA programming • CIS 675-101/851 (Face-to-Face and DL sections) – Evaluation of Information Systems • CIS677-101/851 (Face-to-Face and DL sections) – Principles of Information Systems • MIS 635-101 (one Face-to-Face section) – Management of Telecommunication • MIS 645-101/851 (Face-to-Face and DL sections) – Managing IT for Competitive Advantages	• CIS 679- 101 and 851 (Face-to-face and DL sections) – Management of Information Systems • CIS 675-101/851 (Face-to-Face and DL sections) – Evaluation of Information Systems • CIS 732- 101 and 851 (Face-to-Face and DL sections) – Design of Interactive Systems

Table 9.1 Study Comparisons (Continued)

	Experiment	**Field Studies**
Group Size	Five to seven subjects/group	16 to 28 students/group
Environment	One of the following: • WebBoard only • List Gathering Tool only • Voting tool + WebBoard • SDSS Toolkit (List Gathering Tool + Voting Tool)	SDSS Toolkit (List Gathering Tool + Voting Tool)
Time Period	Three weeks (including training) in the middle of the semester	Two weeks before the end of the semester
Training	Formal two day training for each tool; A set of training tasks needed to be completed before doing the experimental task	No formal training, training website was available for the students. But no formal training task is required to be completed before the exercise.
Control	Control over the tool being used for each condition, Randomly assign subjects into different treatment groups	No control
Task	Computer Purchasing Task (Appendix B.1) – Not a real task for subjects	List most important things learned from the course, then rank order them. – A REAL task for subjects
Results	• Groups with List Gathering Tools support reported to have higher ability to discover valid alternatives. • Groups with SDSS Toolkit support reported to have the highest level of ability to discover valid alternatives. • Graduate student groups were more satisfied with their solution. • Graduate students had longer comments • Coordinators had longer comments • Graduate groups with list gathering support had shorter comments • Manual groups made the longest comments →Graduate students could utilize new technology and appreciate it.	• Students listed all the important concepts in the course. • Some ranking order were not the same as that in instructors' mind. → Successfully used SDSS toolkit to uncover the gap between instructors' design and students' perception.

9.2 Future Directions

The theory of idea collection and organization, its implementation and applications still deserve further study. The research presented in this dissertation is just the first step of the author striving to provide a good structure to groups in order to assist them in organizing their ideas in an easier and clearer manner. Through the experiment and field studies, the List Gathering Tool has demonstrated its strength in helping groups organizing ideas. Yet, it can be further improved and combined with the voting tool to achieve the goal of truly dynamic voting process. Further GSS and CSCW studies need be carried out to investigate the effects of such a toolkit in a group decision-making process.

In light of the above opportunities, further research will focus on the following directions:

1. This dissertation has presented a prototype of one component of a SDSS system. The overall effort produced a great many suggestions for improving both the interface and the functionality of the interface.

   The following improvements can be made to the interface:

   - Use bigger font size or icon to display links. In order to let users get an idea about all the functions the system provides at the first glance, main functions were listed in one single frame on top of the screen. To save space on the screen, small size texts were utilized. This results difficulty of identifying texts in small monitors. To solve this problem, bigger font size or icon should be used instead.
   - Use icons to identify Pro/Con/Neutral comments in the list index. While each comment was identified as "pro", "neutral", or "con", the type of a comment was not displayed in the list index. Only when a user checks the detail of a comment can he/she see the different types of comments. A small icon (e.g., "+" for pro, "-" for con, and "=" for neutral) illustrates the

type of the comment should be displayed beside the title of a comment in the list index so that users can easily see the difference among opinions.

- Allow users to set preference defining the order of lists or items. By default, items were displayed according to the time they were posted. Newly posted items were displayed on the top. This mechanism works better in a conferencing system when users care about the newest postings the most. However, this does not work if users have a particular sequence in their mind when they post their ideas. For example, users may post items that they think the most important first and would like to place it on the top of the list. Therefore, the system should give users the ability to set preference to define the order of items in the list.

The following added functionality would improve the scope of the applications this system can handle:

- Provide the ability to propose deletion/merging/splitting items to reduce overlaps. As the number of users and items grows, as was the case in the field studies, it became clear that the feature of proposing alternative wordings was insufficient. There were overlaps between items. The users need to be able to not only propose a rewording but to be able to propose a deletion as well a rewording. In addition a combination proposal where a user may propose a rewording for a specific item and deletion of one, or two other items or a splitting proposal where a user may propose to divide one item into two separate items as well all incorporated as one vote. Even though the monitor can edit the list and perform these tasks in the current system, the overall objective of the SDSS system is to minimize the need for human facilitation or leadership.

- Make history records available for users to check. During the group discussion, some changes may be made to the list. For example, replaced the original item with the better wording suggested by other group members, deleted unrelated items, etc. All these changes are stored in the database as history records. Even though the original item was replaced by other wordings, discussions on the original item are still kept in the list. If a group member or someone newly introduced into the group reads these comments after the discussion is over, it may surprise him/her because the item that was originally commented on is not there anymore. In this case, historical data will help the group member to get a clearer idea on what has happened to the list during the discussion.
- Make the distinction between modifications and comments clearer. The objective of separating modifications and comments is to let the suggestion on better wording stands out from all other comments so that it can obtain immediate attention from group members. Although definitions on the modification and the comment have been given to subjects, some subjects still complained that they did not know the difference between modifications and comments, and therefore, did not know when to use which one or just used comments for everything. On one hand, this was due to their familiarity with other conferencing system, such as the WebBoard; on the other hand, some subjects felt that it sends an offensive

signal to the original author if they post a mark on their comments claiming that they have better wording. To improve design on this, the above concerns need to be taken into account.

2. The current SDSS system toolkit has shown the ability to conduct a three round Delphi for gathering and voting on a list in two phases lasting as short as a week for a motivated group. The same process can take three months when using paper, pencil and physical mail, and even a month when using email messages for delivering and returning questionnaires. In these modes the design team must spend significant time eliminating duplications from the independently produced lists of item suggestions. However, there is still another step possible to reduce the two current phases: produce the list and then vote on the resulting list. This is where the gathering of the list and the voting go on simultaneously. This requires auxiliary features:

- Modifying routines like Thurstone's law to calculate the results when there are very large differences on total votes for any one item.
- Alerting users that items they voted on need to be re-voted because the votes had to be zeroed out when the item was reworded. Another alternative is to ask the voting on the rewording separately if the votes should be zeroed out as an additional yes/no vote.
- There are negotiation processes where having the listing and the voting take place is really necessary because the quick resolution of agreement or disagreement determines the need for proposing more alternatives as soon as it is clear what the voting is looking like. These added alternatives are

already known to at least one party but they do not want to expose their hand until it is clear a more preferred alternative is not going to be accepted.

Adding the above is fairly easy with in the context of the current software design.

3. Replicate this experiment while correcting the problems encountered. For example, give a longer period of time for subjects to carry out the experiment task; conduct all the experimental conditions in the same time period, etc.
4. As an extension of this dissertation, the author would like to conduct a field study which involves large number of real experts to solve a complex issue in their organization through a longer period of time. It would be interested to see how those people adapt to this kind of system in the real world, and what requirements they would like to address for this kind of system.
5. Similar to what were done during several field trials in the classroom, it is also interesting to apply this kind of system in a learning community to see how it affects the community and how the community adapts to this system.
6. Although the instruments used for this experiment were adopted from previous research studies, they turned out to be generally unreliable. This suggests that there is a need to develop and validate a set of reliable instruments to measure the variables.

9.3 Contributions

Rather than forcing people to work on a strict agenda, this research tries to find a way that helps people to work at their own pace. This research provides a system that allows people to adjust their contributions and indicate the relationships among them in a highly easy to do manner. The author set up a structure to deal with a number of related lists simultaneously, such as objectives, criteria and solutions. The system developed by this research effort allows every individual to deal with whatever aspect they want to work with at that time but provides the group as a whole with a view of what is happening on a collective basis.

By conducting a controlled laboratory experiment and several field trials, the author obtained a better understanding on the effects of this web-based collaborative List Gathering Tool in the group decision-making process. The feedback from the experiment and field studies will serve as guidelines to help future efforts in building group decision support tools.

The field trials illustrated how this SDSS Toolkit can be utilized in a collaborative learning environment (both face-to-face and distance learning) to improve teaching and students' learning experience.

The system will work for very practical applications such as a list of project problems or bugs and voting on which are the most serious for immediate treatment and how they have to be resolved to avoid fouling up the work of others in the group.

In today's global economy, it is very common that group members locate in different parts of the world. Such a web-based collaborative List Gathering Tool combined with the voting tool can decrease the effort of collaboration and increase the productivity in a global team when they face very complex problems.

APPENDIX A

RESEARCH INSTRUMENTS FOR PROTOCOL ANALYSIS

This appendix includes all the research instruments used for protocol analysis. They are:

A.1 Protocol Analysis Research Guidelines

A.2 Instructions for Evaluators

A.3 Consent Form

A.4 Background Questionnaire

A.5 Evaluation Task Form

A.6 Post Questionnaire (Interview Guide)

A.1 Protocol Analysis Research Guidelines

A. What you need before you can start

You need to agree with a group of potential users (graduate students, real decision makers, interface experts) that you will work on as potential subjects for this project. You should get their names, phone numbers, and email accounts, if they have one.

Determine the exact location, and the range of dates/times when a PC connected to the Web will be available for you to use in this project. Choose locations that are either private (e.g., an office) or parts of a public places that are relatively quite (e.g., a PC in one of the labs located in a remote corner).

Prepare the following materials;

(1) Your id card.
(2) Instructions that you will read to the subjects prior to beginning the session.
(3) Copies of the consent form, which you will fill out and ask the subjects to sign before beginning any tasks. You should not work with any subjects, prior to their signing off the consent form. You need one questionnaire for every subject that you plan to work with.
(4) Copies of the pre-task questionnaire that you will administer to the subject prior to the beginning of the task. You need one questionnaire for every subject that you plan to work with.
(5) Instructions that you will give to the subject on the task that he/she will accomplish and the general rules to be followed.
(6) Instructions that you will give in writing to the subject to perform the Protocol Analysis task. The subject will keep these instructions during the Protocol Analysis task. At the end of the Protocol Analysis tasks, you will ask the subject to give you back these instructions.
(7) Copies of the post task questionnaire and the script you should follow with every subject. You need one questionnaire for each subject that you plan to work with.
(8) Tape recorder and notepad with lots of blank pages and several pens. You may bring different color pens to help you organize your notes.

B. Site Preparation before any activity

1. Visit the site(s) prior to the dates/times that you expect subject to come to. Verify that there is a PC available, check you can reach the List Gathering Tool Web page and place a bookmark pointing to it in the browser.
2. Talk to the person responsible that PC and request permission to perform your experiment and their cooperation during the dates/times that you plan to use. Ask the person responsible for additional dates/times that you may use if you need to.
3. Contact by phone and/or email each of your potential subjects. Experience shows that 30% of those invited come as promised. So, make sure you invite enough subjects counting on 30% actual respondents. Do not overlap the appointments. If you make the appointments ahead of time, make sure to send reminders on the day before the appointment is due.

4. Plan to arrive earlier on the dates/times of your appointments to ensure that the PC and its surroundings are suitable for your task.
5. Contact the subject to apologize for the inconvenience and ask for rescheduling if due to any circumstance you cannot keep an appointment. At most, if you cannot warn the subject, you should leave a message at the planned meeting place with your apologies and follow up personally later on.

C. Pre-Protocol Analysis Tasks

1. Greet the subject and introduce yourself, if you have not met him/her before.
2. Use a little small talk to make the subject relax and feel at ease. Always be polite.
3. Read your introductory script explaining to the subject how both of you will proceed and ask if he/she has any questions. After all questions are answered (this should not take longer than 5 minutes), explain to the subject the reason and purpose of the consent agreement and ask him/her to sign it. If the subject is hesitant or does not want to sign, proceed to administer the post the Protocol Analysis questionnaire and thank him/her for coming over.
4. After the subject has signed, the consent agreement form, hand him/her a copy of the background questionnaire and ask them fill it out (The questionnaire can also be put online, so the subjects can fill them online).
5. After finishing the background questionnaire, hand him/her a copy of the tasks to be performed and verify if they remember what to do and how to proceed.
6. Try to finish the task within 30 minutes. If subjects cannot finish it within 30 minutes, stop there. Proceed to post-questionnaire.

D. Protocol Analysis Tasks

1. Make sure that you have a clean (unmarked) copy of the protocol analysis tasks.
2. Use a tape recorder and a notepad to record and/or take notes of anything that happens during the Protocol Analysis. Politely state that the purpose of exercise is to listen and let them perform their task without your help or intervention. Give the subject up to 30 minutes to complete tasks. It does not matter if all the tasks are not completed.

E. Post-Protocol Analysis tasks

1. After the 30 minutes are all over or subject finishes the tasks, thank the subject for his/her cooperation and administer the post-questionnaire.
2. Thank the subject again and do some small talk for a couple of minutes to answer his/her questions, and ensure that the subject is relaxed and convinced of your gratefulness. Make sure that the small talk does not go beyond couple of minutes; if necessary, excuse yourself from carrying on with the conversation on the basis that you expect other respondents.
3. Show and express gratefulness and satisfaction with the outcome of your interview REGARDLESS OF WHAT ACTUALLY HAPPENED. Remember that the purpose of these experiments is TO FIND OUT HOW THE SUBJECTS FEEL AND REACT TO THE TASK-NOT FOR YOU TO ACHIEVE ANY PERSONAL GOALS BEYOND THE RECODING OF THE SUBJECTS OPINIONS AND BEHAVIOR.

4. DO NOT FEEL PERSONALLY AFFECTED BY ANYTHING THAT SUBJECTS MIGHT DO OR SAY. There are no right or wrong responses to the protocol analysis task. Your role is to OBSERVE and record information not to make judgments.

F. Closing tasks

Organize all the material and notes collected during the interview.

Make sure you write down in your notes any relevant information that you did not record during the interview, or some comments that came to your mind after the interview. Please ensure that you keep your opinions and comments entirely separate from those of your respondents.

Take a few minutes break. Interviewing subjects is a stressful task and even the pros take frequent breaks to ensure that they are ready for the next interview. Allow extra time in your scheduling for these breaks.

A.2 Instructions for Evaluators

Instructions for Evaluate the Web-based List Gathering Tool

Thank you for volunteering to assist in evaluating a new software system. Your feedback will be used to make specific improvements to the system. This exercise should take about 30 minutes. I hope it will be an interesting experience for you. The system you will be exploring is a Website that is used to help a group of people to collect a list of ideas.

The method we are using to try to find out how this system looks to you is called "thinking out loud". You will try to use the system to perform some tasks which I will give it to you, and tell me what you see on the screen, what you understand or do not understand about what you see, what you decide to do based on what you see. I would also like you to verbalize any feelings you may have about how the system is acting.

Your main task will be to tell me what you are thinking as you look at the various screens of the system. Please be as specific and detailed as possible. The version of the software you will be using is still under developing. Any suggestions from users will be great help for improving the current version of the software. You can click anywhere you want to get into the screens that follow that action. Basically, you can try everything in the screen, which will be evaluated.

For each screen, please tell me all of the actions that you think you would be able to accomplish based on what you see. These actions include highlighting various items on the screens and pressing keys on the keyboard. For each of the available actions, also indicate what you think would happen if the action was taken. In addition, please verbalize your interpretation of the meaning of all terms and phrases on each screen.

You should also indicate anything that you are uncertain of. However, I will not be able to provide you with any assistance. The goal of this exercise is to determine how easy this system is to use by someone without access to an experienced user.

You do not need to verbalize when you are reading or concentrating on making a decision.

While you are talking, I will be recording your response. This information will be used for later analysis to make improvements to the system based on your comments. In addition, a summary will be prepared based on the results of your evaluation. However, you will not be identified in that report.

Although I will not be able to answer any of your questions during this exercise, I will use hand signals in case there is some additional information I would like you to provide. Specifically, I will point to an item on the screen that I would like you to talk about further. Hand signals will be used to minimize distractions to your thinking process. If necessary, I may ask you the following questions: what are you thinking? Or what does that term mean?

Please tell me before you press the button (or link) to go to the next screen so I have a chance to prompt you for more information if needed.

Please remember, I am evaluating the Web-based list gathering tool, not you. Be sure to tell me everything you are thinking and describe everything you see on the screen. Now get ready to have some fun!

To begin, please go to the address I gave you to see the first page of the system.
At the end of this exercise, I would like you to complete a brief questionnaire about your experience.

A.3 Consent Form

Name of Project Director or Principal Investigators: **Yuanqiong Wang**

Title of Project:
Using Protocol Analysis to Evaluate the Web-Based List Gathering Tool
I acknowledge that on ______________________(Date), I was informed by *Yuanqiong Wang* (Investigators) of NJIT (under the supervision of Dr. Roxanne Hiltz) of a project concerning or having to do with the following:
Using Protocol Analysis to Evaluate the Web-Based List Gathering Tool

I was told with respect to my participation in said project that:
1. *The following procedures are involved:*
   a. Carrying out one or more tasks using the List Gathering Tool
   b. Filling out several questionnaires
   c. All communications during the tasks will be recorded, and later analyzed.

2. The following possible risks are involved:
   No known risk; confidentiality of the data will be fully protected.

3. The following possible alternative procedures that may be advantageous to me include:
   An alternative assignment relevant to the topic of the experiment will be given.

4. The following benefits are expected by my participation:
   - An opportunity to learn about how to evaluate a software,
   - An opportunity to contribute to the design of better computer systems to support decision-making.

I am fully aware of the nature and extent of my participation in said project and possible risk involved or arising there-from. I hereby agree, with full knowledge and awareness of all of the foregoing, to participate in said project. I further acknowledge that I have received a complete copy of this consent statement. I also understand that I may withdraw my participation in said project at any time without any negative consequences.

Signature of Subject or Responsible Agent: ______________________________

Printed Name of Subject: ____

Date: ____

Email address: ____

Phone Number: ____

A.4 Background Questionnaire

Name: ________________________ Date: ________________________

The purpose of this questionnaire is to gather some background information. All information is confidential.

Please check the answer(s) which applies to you:

1. I am an: ____Undergraduate junior ____MBA student _____ Ph.D. student
   ____Undergraduate senior ____MSIS student _____ MSCS student
   ____other; please specify ___________________

2. My undergraduate major is/was:
   _____ accounting _____ management
   _____ finance _____ marketing
   _____ information systems _____ engineering
   _____ other; please specify: ________________

3. My nationality is: _________________

4. My ethnic background is:

   _____ Black/Afro American
   _____ Hispanic (Mexican, Puerto-Rican, etc.)
   _____ White
   _____ Asian or Asian American
   _____ Other

5. I am a: _____ female _____ male

6. My age is: _____ under 23 _____ 31-40
   _____ 23-30 _____ over 40

7. English is my native or first language. _____ Yes _____ No
   If you were **not born in the US**, the number of years you have lived in the US _______

8. The total number of months I have been employed full-time (Do count summer or other vacation jobs if worked full-time) ____________ months

9. Average number of hours I use the Internet per day is:
   _____ Never _____ less than half hour
   _____ half to one hour _____ over 1 hour

10. Have you ever used any decision support tool? _____ Yes _____ No
    If your answer is **yes,** please specify: ______________________________

Directions: After each statement, circle the answer that applies to you. There are no right or wrong answers. Work quickly; just record your first impression.

11. My confidence in contributing information and insight to a group taking the responsibility to recommend would be:

very high	high	medium	low	very low
1	2	3	4	5

12. When it comes to computers, I consider myself a:

novice 1------------2-----------3---------4----------5 expert

13. My level of experience in working in groups is:

very high	high	medium	low	very low
1	2	3	4	5

14. My level of experience in making actual business decisions is

very high	high	medium	low	very low
1	2	3	4	5

15. I dislike participation in group discussions.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1	2	3	4	5

16. Engaging in group discussions with new people makes me tense and nervous.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1	2	3	4	5

17. Generally, I am comfortable participating in group discussions.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1	2	3	4	5

A.5 Evaluation Task Form

Please try to finish the following tasks:

1. Sign up on the List Gathering tool. If you do not want to use your own email address, you can use the following email address: list_evaluate@yahoo.com.
2. Please contribute one root item under "Evaluate" List.
3. Please suggest a better wording for the item "First impression".
4. Please post your comment on the item "First impression".
5. Please cast your vote on the better wording you just suggested.

A.6 Post Questionnaire (Interview Guide)

Thank you for participating in this activity. Please answer the following questions:

1. Which feature do you think would be most useful?

2. Which feature do you think would be least useful?

3. What features should be added to this system?

4. What features should be removed from this system?

5. What changes would you recommend to make the system easier to use?

Directions: After each statement, circle the answer that applies to you. There are no right or wrong answers.

1. The list gathering tool is easy to learn.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1	2	3	4	5

2. The interface of this system is confusing.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1	2	3	4	5

3. I would like to recommend this system to my friends.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1	2	3	4	5

4. I don't know where to start when I log in to the system.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1	2	3	4	5

APPENDIX B

EXPERIMENTAL INSTRUMENTS

The following documents are instruments used for the experiment. They are:

B.1 Experiment Overview Letter

B.2 Training Materials

B.3 Experimental Task

B.4 Consent Form

B.5 Background Questionnaire

B.6 Task Survey

B.7 Post Questionnaire

B.8 System Survey

B.9 Instruments for Expert Judges (Group Reports)

B.10 Instruments for Expert Judges (Criteria Lists)

B.1 Experiment Overview Letter

Experimental Overview

You are invited to participate in a research project that will investigate a Social Decision Support System (SDSS). Participation in this project will take about three weeks, in which four days are for training and the other two weeks to work on the research task.

During the experiment, first, you will be required to complete an online training session within four days. After the training session, you should be able to know how to use the systems which you are going to use to carry out the experimental task. Then, you will be required to complete the experimental task ONLINE using that system within two weeks. No face-to-face meetings are required.

You will be asked to complete several questionnaires online, most of which relate to the task and the group experience. Some of your background information will also be collected. The questionnaires you are required to complete are Consent Form, Background Questionnaire, Task Survey, Post-Questionnaire, and System Survey.

If you are willing to participate in the experiment, please fill out the Consent Form and the Background Questionnaire online at the following URLs before Oct. 12, 2002:

1. Consent Form:
http://westwing.njit.edu/Questionnaires/Consent_Form.cfm
2. Background Questionnaire:
http://westwing.njit.edu/Questionnaires/Background_Questionnaire.cfm

Please use your VALID Email address and the FULL NAME (First name + Last name) that appears on the class roster to fill out the forms. We will contact you via email upon receiving your Consent Form and the Background Questionnaire to further inform you the experimental details.

Participation in this project will provide you with an opportunity to learn about experimental design and procedures, and to contribute to the design of better computer systems to support group decision-making. There is no risk involved. All data will be held in the strictest confidence.

You will be given class credit for your participation. You may choose not to participate in this project. And your decision to participate or not will in no way influences your grade. If you choose not to participate in the research, you will be assigned an alternate task, which will be given by your professor.

For further information or any other questions please feel free to contact the researchers at: njitexp@hotmail.com

Sincerely,

Yuanqiong Wang, Zheng Li (Email: njitexp@hotmail.com)

B.2 Training Materials

1. WebBoard Training Material
http://westwing.njit.edu/Training/Webboard/Overview.htm

2. List Gathering Tool Training Material
http://westwing.njit.edu/Training/List/Overview.htm

3. Voting Tool Training Material
http://westwing.njit.edu/Training/Vote/Overview.htm

4. SDSS Toolkit Training Material
http://westwing.njit.edu/Training/SDSS/Overview.htm

B.3 Experimental Task

B.3.1 Task Description

Computer Equipment Purchasing Task

Background

You are an employee of a small state university. The university is about to make a new purchase of approximately 800 personal computers for the next academic year and establish the vendor who will be supplying personal computers (desktop models) for at least a three year period at a minimum rate of 600 machines per year. This will be a major upgrade of personal computers for many faculty and staff members and new machines for about 500 entering freshmen. A RFP (Requests for Proposal) is required. In past RFPs, the university has had proposals from such companies as IBM, Dell, Gateway, Compaq, Hewlett-Packard, Micron, DTK, Acer, NEC, and Toshiba. It has also had proposals in the past from companies that no longer exist. As a state university it must be very clear in the RFP as to the criteria by which a winning bid will be awarded and the winning bid as well as the RFP becomes a public document. A loser in this contest, after examining the winning bid, could actually sue if they felt the award went to a company that did not respond as well as they did to the RFP.

It is known that the university can afford for the budget for this purpose machines costing up to $1500 per machine. But individuals can add more dollars from other sources to increase the power of the machine they get from the vendor. The university has a normal mix of academic disciplines and a range of faculty and staff from novice and casual users to power users.

Task

You have been invited by the CIO (Chief Information Officer) and the President of the University to be a member of the Task Force charged with defining the specific requirements or criteria that will be used in the RFP to choose among the vendors and their machines. The objectives of your Task Force are:

- To establish the set of absolute and relative criteria to choose the vendor and the machines,
- To arrive at a relative importance (rank order) of all relative criteria,
- To provide the supporting reasons for the criteria and their relative importance,

Absolute criteria are items like:

- The machine must have a minimum of 128MB of core memory,
- The base machine must not cost more than $1,500,
- The machine must contain a CD-RW drive.

Relative criteria are items like:

- Exceeding the minimum core memory requirement in the proposed base machine,
- The reputation for reliability of the proposed manufacture (which may be different from the bidder),
- The service reputation of the bidder.

The only absolute criterion that has already been determined is that the base machine will not exceed $1,500. Any others are your choice. Be careful that your absolute requirements do not result in it being impossible to configure a base machine for $1,500 or less. Individual students, faculty and staff may add funds from other sources and budgets to request a more powerful machine from the vendor so that the bidder needs to supply the costs of additions to the base machine.

You have two weeks to work on this task. At the end of the second week, your Task Force needs to submit a group report. The report will be reviewed by the Committee on Academic Affairs (Deans and Chairs), the CIO, the President and the Provost, and then turned over to the Purchasing and Legal departments for the final composition of the RFP.

The contents of this report must include (Please refer to the attached file for the format of the Final Report):

1. *A description of each of the absolute criteria.*
2. *Reasons for choosing each absolute criterion.*
3. *A description of each of the relative criteria.*
4. *Reasons for choosing each relative criterion.*
5. *The relative importance of each of the relative criteria as a rank-ordered list.*
6. *Reasons that support the final order of importance for the relative criteria.*

It is an honor being selected to work on this fundamental analysis required for the final RFP. With this project, you will be able to help your university to make the important choice of a vendor to deliver improved services and Personal Computer options to the university community.

B.3.2 Group Report Template

This is a document that groups used as a template for their group reports.

Computer Equipment Purchasing Task

Final Report

Submitted by:

Member 1

Member 2

… …

Member N

Date: mm/dd/yyyy

Table of Contents

EXECUTIVE SUMMARY

Your executive summary goes here. Please make it no longer than one page.

1. ABSOLUTE CRITERIA

1.1 Description of each of the absolute criterion

Your list of absolute criteria goes here. It should look like:
1. Item1…blabla
2. Item2…blabla
3. Item3… blabla
4. …

1.2 Reasons for choosing each absolute criterion

1. Item1 … blabla.

   Reason: your reason of item1 goes here.

2. Item2 … blabla

   Reason: your reason of item2 goes here.

3. … …

1.3 Any General Observations (Optional)

blablabla

2. RELATIVE CRITERIA

2.1 Description of each of the relative criterion

Your list of RANK-ORDERED relative criteria goes here. It should look like:
1. Item1…blabla
2. Item2…blabla
3. Item3… blabla
4. …

2.2 Reasons for choosing each relative criterion

1. Item1 … blabla.

   Reason: your reason of item1 goes here.

2. Item2 … blabla

   Reason: your reason of item2 goes here.

3. …… …

2.3 Reasons that support the final order of importance for the relative criteria

Your reason for obtaining the order of importance for the relative criteria goes here. Please explain the voting process and how you get the final order.

2.4 Any General Observations (Optional)

blablabla

3. CONCLUSION AND SUMMARY CHARTS

3.1 Conclusion

Your conclusion goes here.

3.2 Summary Charts

The summary charts include two tables:

1.Table of absolute criteria

No.	Description	Reason
1	Item1	
2	Item2	
3	……	

2. Table of rank ordered relative criteria

Rank	Description	Reason	Member 1's vote*	Member 2's vote*	… …	Member N's vote*
1						
2						
3						

* "Member N's vote" can use that member's initials as the column name. For example, for group member Kathy Jane, you should put KJ in that cell.

B.4 Consent Form

CONSENT FORM

Name of Project Director or Principal Investigators: **Zheng Li and Yuanqiong Wang**

Title of Project: **Social Decision Support Systems in Distributed Group Support Systems**

I acknowledge that on 06/17/2003, I was informed by **Zheng Li and Yuanqiong Wang** (Investigators) of NJIT (under the supervision of Dr. Roxanne Hiltz) of a project concerning or having to do with the following:

Computer Supported Social Decision Making in Distributed Group Support Systems

I was told with respect to my participation in said project that:

1. The following procedures are involved:
   - Carrying out one or more decision tasks
   - Filling out several questionnaires
   - All communications during the decision-making task will be recorded, and later analyzed.

2. The following possible risks are involved:
   No known risk; confidentiality of the data will be fully protected.

3. The following possible alternative procedures that may be advantageous to me include:
   An alternative assignment relevant to the topic of the experiment will be given.

4. The following benefits are expected by my participation:
   - An opportunity to learn about experimental design and procedures,
   - An opportunity to learn decision making techniques,
   - An opportunity to contribute to the design of better computer systems to support social decision-making.

I am fully aware of the nature and extent of my participation in said project and possible risk involved or arising there-from. I hereby agree, with full knowledge and awareness of all of the foregoing, to participate in said project. I further acknowledge that I have received a complete copy of this consent statement. I also understand that I may withdraw my participation in said project at any time without any negative consequences.

Name: ____________________ Semester: ________________
Email: ____________________ Professor: ________________
Phone: ____________________ Course #: ________________

B.5 Background Questionnaire

Background Questionnaire

The purpose of this questionnaire is to gather some background information. All information is confidential.

Part I. Please check the answer(s) which applies to you:

1. I am an: _____ Undergraduate junior _____ MBA student
   _____ Undergraduate senior _____ MSIS student
   _____ Ph.D. student _____ MSCS student
   _____ Other; please specify ___________________

2. My undergraduate major is/was:
   _____ Accounting _____ Management
   _____ Finance _____ Marketing
   _____ Information Systems _____ Engineering
   _____ Other; please specify: ________________

3. My nationality is: ________________

4. My ethnic background is:
   _____ Black/Afro American
   _____ Hispanic (Mexican, Puerto-Rican, etc.)
   _____ White
   _____ Asian or Asian American
   _____ Other

5. I am a: _____ female _____ male

6. My age is: _____ under 23 _____ 31-40
   _____ 23-30 _____ over 40

7. English is my native or first language. _____ Yes _____ No
   If you were **not born in the US**, the number of years you have lived in the US _______

8. The total number of months I have been employed full-time (Do count summer or other vacation jobs if worked full-time) ____________ months

9. I have used WebBoard _____ Never _____ Three to ten times
   _____ Once or twice _____ Frequently

10. I have bought computer(s) or workstation(s) before. _____ Yes _____ No

If **Yes**, please answer the next two questions, otherwise skip them.

10.1. I bought it for _____ myself _____ organization _____ other
10.2. I have bought computer(s) _____ once _____ twice
_____ more than two times

Part II.
Directions: After each statement, circle the answer that applies to you. There are no right or wrong answers. Work quickly; just record your first impression.

1. My confidence in taking the responsibility to recommend a choice for a personal computer for an organization would be:

very high high medium low very low
1---------------2------------------3--------------4------------------5

2. My confidence in contributing information and insight to a group taking the responsibility to recommend would be:

very high high medium low very low
1---------------2------------------3--------------4------------------5

3. When it comes to computers, I consider myself a:

novice 1-------------2------------3---------4-----------5 expert

4. My level of experience in working in groups is:

very high high medium low very low
1---------------2------------------3--------------4------------------5

5. My level of experience in making actual business decisions is

very high high medium low very low
1---------------2------------------3--------------4------------------5

6. I dislike participation in group discussions.

Strongly Agree Agree Undecided Disagree Strongly Disagree
1---------------2------------------3------------------------4------------------5

7. Engaging in group discussions with new people makes me tense and nervous.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1	2	3	4	5

8. I have easy access to WebBoard from home or work.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1	2	3	4	5

9. Generally, I am comfortable participating in group discussions.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1	2	3	4	5

B.6 Task Survey

Task Survey

Part I. Please rate the task on each of the following dimensions by writing down the number which most closely matches your opinion.

1. How much effort was required to complete this task?

very little effort	some effort	average effort	A lot of effort	extraordinary effort

1--------------------2--------------------3------------------4---------------------5

2. To what degree do you think the task was interesting and motivating to you?

extremely boring	neutral	extremely interesting

1--------------------2--------------------3------------------4--------------------5

3. How important was it for you to complete this task?

not important	moderately important	critical

1---------------------2--------------------3-----------------4--------------------5

4. How easy or difficult did you find this task as an individual?

extremely easy	neutral	extremely difficult

1--------------------2--------------------3------------------4--------------------5

5. How enjoyable did you find to work on this task using the procedures and system provided?

extremely unpleasant	neutral	extremely enjoyable

1--------------------2--------------------3------------------4--------------------5

6. Did the task description provide you with enough information to easily carry out the task?

definitely	somewhat	not at all

1--------------------2--------------------3------------------4--------------------5

7. Did the task description make it clear what was to be accomplished?

unclear	fairly clear	very clear

1--------------------2--------------------3------------------4--------------------5

8. Was there a clearly defined body of knowledge that could guide you in doing this work?

definitely	somewhat	not at all

1--------------------2--------------------3------------------4--------------------5

9. Was there an understandable approach that could be followed in doing your contributions to the task?

definitely		somewhat		not at all
1	2	3	4	5

10. To what extent did you feel you had the background (education and/or experience) needed to carry out this task?

not at all	little extent	some extent	great extent	very great extent
1	2	3	4	5

Part II. Please give short comments on the following questions:

1. Below please identify any aspect of the task or the task materials that you found to be confusing or difficult to understand (for example, instructions, vocabulary, etc).

2. Below please write down your own ideas about what are the most important absolute criteria and what are the most important relative criteria that come to your mind.
IMPORTANT NOTE: Please do NOT refer to your group report/discussion. DO THIS FROM YOUR OWN MIND!

B.7 Post Questionnaire

Post-Questionnaire

Part I. Please circle one number based only on your experience with your group.

1. The overall quality of the group's work was:

   Poor 1----2----3----4----5 Good

2. The issues explored during the group's work were:

   Trivial 1----2----3----4----5 Substantial

3. The content of the group's work was:

   Carefully developed 1----2----3----4----5 Carelessly developed

4. The manner in which the participants examined issues was:

   Non-constructive 1----2----3----4----5 Constructive

How would you describe your group's problem-solving process?

5. Efficient	1	2	3	4	5	Inefficient
6. Coordinated	1	2	3	4	5	Uncoordinated
7. Fair	1	2	3	4	5	Unfair
8. Understandable	1	2	3	4	5	Confusing
9. Satisfying	1	2	3	4	5	Unsatisfying

10. How satisfied or dissatisfied were you with the quality of your group's solution?

    Very dissatisfied 1----2----3----4----5 Very satisfied

11. To what extent does the group's work reflect your inputs?

    Not at all 1----2----3----4----5 Very great extent

12. To what extent do you feel committed to the group's solutions?

    Not at all 1----2----3----4----5 Very great extent

13. Issues raised in the group were discussed thoroughly.

    Strongly agree 1----2----3----4----5 Strongly disagree

14. To what extent are you confident that the group's solutions are correct?

Not at all 1----2----3----4----5 Very great extent

15. I am in complete agreement with the group's work.

Strongly agree 1----2----3----4----5 Strongly disagree

16. The group discussions enabled me to better understand the positions of other members of my group.

Strongly agree 1----2----3----4----5 Strongly disagree

17. The group decision process uncovered valid alternatives that I had not considered.

Strongly agree 1----2----3----4----5 Strongly disagree

18. The group decision process made me critically reevaluate the validity of the alternatives that I had thought of.

Strongly agree 1----2----3----4----5 Strongly disagree

19. I experienced pressure, either to conform to a particular viewpoint or not to contradict others.

Very much 1----2----3----4----5 Not at all

20. I tried to go along with the group consensus even if I disagreed somewhat.

Strongly agree 1----2----3----4----5 Strongly disagree

21. To what extent did the group experience conflict?

Not at all 1--------2-------3--------4----------5 Very much

22. Did the group handle conflict effectively?

Not at all 1--------2-------3--------4----------5 Very much

23. Did the group members acknowledge and confront conflict openly?

Not at all 1--------2-------3--------4----------5 Very much

24. Our group's approach helped us to resolve conflicts that arose in the course of our work.

Strongly agree 1-------2-------3-------4-------5 Strongly disagree

25. The system used in the experiment resulted in information overload.

Strongly agree 1-------2-------3-------4-------5 Strongly disagree

26. The system used in the experiment increased the amount of the irrelevant information making it harder to focus on what needed to be done.

Strongly agree 1-------2-------3-------4-------5 Strongly disagree

27. The system used in the experiment caused me to miss important information.

Strongly agree 1-------2-------3-------4-------5 Strongly disagree

Part II. Other measurements:

1. Participation in the group's work was:

Unevenly distributed1----2----3----4----5 Evenly distributed

2. The group members dealt with the issues:

Systematically 1----2----3----4----5 Non-systematically

3. The interpersonal relationships among the group members appeared to be:

Unhealthy 1----2----3----4----5 Healthy

4. The group was:

Not goal directed 1-----2----3----4----5 Goal directed

5. The group members initiated discussions on:

Relevant issues 1-----2----3----4----5 Irrelevant issues

6. The group members' contributions were:

Poorly amplified 1-----2----3----4----5 Well amplified

7. Participation in the discussions was:

Unevenly distributed 1-----2----3----4----5 Evenly distributed

8. Ideas expressed in the discussions were:

Critically examined 1-----2----3----4----5 Uncritically examined

9. I felt frustrated and tense about others' behavior.

Strongly agree 1----2----3----4----5 Strongly disagree

10. I rejected others' opinions or suggestions.

Strongly agree 1----2----3----4----5 Strongly disagree

11. My opinions or suggestions were rejected.

Strongly agree 1----2----3----4----5 Strongly disagree

12. All of the group members showed attention and interest in the group's activities.

Strongly agree 1----2----3----4----5 Strongly disagree

13. I felt reluctant to put forward my own ideas.

Very much 1----2----3----4----5 Not at all

14. There was a high degree of participation on the part of members.

Strongly agree 1----2----3----4----5 Strongly disagree

15. The work of the group was left to those who were considered most capable for the job.

Very much 1----2----3----4----5 Not at all

16. There were long periods during which the group did nothing.

Very much 1----2----3----4----5 Not at all

17. The work of the group was well divided among members.

Strongly agree 1----2----3----4----5 Strongly disagree

18. Every member of the group did not have a job to do.

Strongly agree 1----2----3----4----5 Strongly disagree

19. The language of the group prevented participation.

Strongly agree 1----2----3----4----5 Strongly disagree

20. One or two members strongly influence the group decisions.

Strongly agree 1----2----3----4----5 Strongly disagree

21. I feel one person influenced the group's work more than the rest of the group.

Strongly agree 1----2----3----4----5 Strongly disagree

22. Someone (other than the assigned group coordinator) emerged as an informal leader.

Strongly agree 1----2----3----4----5 Strongly disagree

23. The group coordinator performed his/her functions well.

Strongly agree 1----2----3----4----5 Strongly disagree

24. To what extent were the people in your group friendly?

Very friendly 1----2----3----4----5 Not friendly at all

25. To what extent were the people in your group helpful?

Very helpful 1----2----3----4----5 Not helpful at all

26. To what extent did the people in your group take a personal interest in you?

Very interested 1----2----3----4----5 Not interested at all

27. To what extent did you trust the members in your group?

Great deal of trust 1----2----3----4----5 No trust at all

28. To what extent did you look forward to working with the members of your group?

Very much 1----2----3----4----5 Not at all

29. All the members of the group contributed to the final result.

Strongly agree 1----2----3----4----5 Strongly disagree

B.8 System Survey

System Survey

Part I.
Please rate the system you used for the experiment on each of the following dimensions by selecting the number which most closely matches your opinion.

Q1. The system was easy to learn.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1	2	3	4	5

Q2. The training materials of the system were easy to follow.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1	2	3	4	5

Q3. I would like to recommend this system to my friends.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1	2	3	4	5

Q4. I don't know where to start when I log in to the system.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1	2	3	4	5

Q5. The interface of the system was confusing.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1	2	3	4	5

Q6. The training on the system was helpful for me to carry out the experimental task.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1	2	3	4	5

Q9. I used the system without needing much help.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

1--------------2-----------------3-----------------------4-----------------5

Q10. I needed to use help a lot on the system.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

1--------------2-----------------3-----------------------4-----------------5

Mark your answers on the scale, expressing your opinions on your impressions of the system.

Q8. Easy to understand	1 2 3 4 5 6 7	Hard to understand
Q11. Easy to use	1 2 3 4 5 6 7	Hard to use
Q12. Clear	1 2 3 4 5 6 7	Confusing
Q13. Intuitive	1 2 3 4 5 6 7	Unintuitive
Q14. Fast	1 2 3 4 5 6 7	Slow
Q15. Sufficient Feedback	1 2 3 4 5 6 7	Little Feedback
Q16. Friendly	1 2 3 4 5 6 7	Unfriendly

Q17. While using the system I felt challenged to do my best work.

Strongly agree 1----2----3----4----5----6----7 Strongly disagree

Q18. I felt frustrated by using the system.

Strongly agree 1----2----3----4----5----6----7 Strongly disagree

Q19. Using the system was fun.

Strongly agree 1----2----3----4----5----6----7 Strongly disagree

Q20. I really feel my work on the system accomplished something.

Strongly agree 1----2----3----4----5----6----7 Strongly disagree

Q21. While using the system, I felt comfortable.

Strongly agree 1----2----3----4----5----6----7 Strongly disagree

Q22. I enjoyed using the system.

Strongly agree 1----2----3----4----5----6----7 Strongly disagree

Q23. I don't like the system.

Strongly agree 1----2----3----4----5----6----7 Strongly disagree

Thinking back over your experience so far with the system, how frequently have you felt

	Almost Always	Most of the time	Some times	Almost never	Never
Q25. Distracted by the mechanics of the System	○	○	○	○	○
Q26. Constrained by the System Design	○	○	○	○	○
Q27. Overloaded with information	○	○	○	○	○
Q28. Able to understand	○	○	○	○	○

Part II. Other measurements:

Q2.1. Which features do you think are the most useful?

Q2.2. Which feature do you think is the least useful?

Q2.3. What features should be added to this system?

Q2.4. What features should be removed from the system?

Q2.5. What changes would you recommend to make the system easier to use?

Q2.6. What changes would you recommend to make the system more effective for the task you were given?

B.9 Instruments for Expert Judges (Group Reports)

B.9.1 Guidelines for Judge Training

GUIDELINES FOR JUDGE TRAINING

1. All judges will be in the CoLab together for training.
2. We choose three groups' reports from the pilot studies.
3. The "Computer Purchasing Task" and the final report template will be distributed to the judges.
4. The judges rating form and instructions will be distributed to the judges and reviewed. The linkages between the task requirements and the rating form will be explained.
5. The judges will read the first report and rate them. After all judges have finished, we will copy each judge's answers to the whiteboard so that everybody can see how others voted. Large discrepancies will be discussed until consensus is reached. (The first report will be a good report)
6. The same procedure will be followed for the second report. (The second report will be a relatively poor report)
7. After each report's rating is discussed, the judging for the two reports will be compared. Judges will then have the opportunity to re-judge each group's report.
8. If time permits, the same procedure will be followed for the third report.(The third report will be an average report)
9. After training session, distribute the reports to judges. The order of the reports will be staggered so that no two judges will judge exactly the same set of reports.

<u>Contents of Judges' packet:</u>

- Computer Purchasing Task and final report template
- Evaluation Forms (one for each report)
- Instruction for Judges
- Three reports from the pilot study
- 11 reports from the experiment (after training session)

B.9.2 Instructions for Expert Judges

INSTRUCTIONS FOR EXPERT JUDGES

1. **Content of the report**
   - **Absolute Criteria Quality:** whether or not the description of each absolute criterion is clear and understandable, and whether the list of the absolute criteria is complete.
   - **Reasons to support the Absolute Criteria selection:** whether the reasons for choosing the absolute criteria in the report support their argument.
   - **Relative Criteria Quality:** whether or not the description of each relative criterion is clear and understandable, and whether the list of the relative criteria is complete.
   - **Reasons to support Relative Criteria selection:** whether the reasons for choosing the relative criteria in the report support their argument.
   - **Quality of Relative Criteria ranking orders:** whether the rank orders for the relative criteria are reasonable and whether the reasons for the final ranking of the relative criteria in the report support their argument.
2. **Presentation format**
   - **Clarity and Completeness:** whether the report is clear and well organized, and whether the report included all the required sections.
3. **Creativity (Originality):** whether the report has any creative/unique ideas.
4. **Overall quality of the report:** Overall, how well the report was written.

B.9.3 Evaluation Form

EVALUATION FORM

REPORT ID: ________________

Instructions: For each of the features below, rate the group's final report on a scale of 1 to 10, with 1 being poor and 10 being excellent.

I. Content of the report

- Absolute Criteria Quality ____________
- Reasons to support Absolute Criteria selection ____________
- Relative Criteria Quality ____________
- Reasons to support Relative Criteria selection ____________
- Quality of Relative Criteria ranking process ____________
- Quality of Relative Criteria ranking orders ____________

II. Presentation format

- Clarity and Completeness ____________

III. Creativity (Originality) ____________

IIII. Overall quality of the report ____________

B.10 Instruments for Expert Judges (Criteria Lists)

B.10.1 Letter to Expert Judges

We have gathered for you all the unique absolute criteria and relative criteria that the working groups in this experiment generated according to the problem scenario we have provided you.

You will find we divided all the criteria in to the following types:

Absolute Category	No. Of Unique items	Relative Category	No. Of Unique items
RAM	19	Memory	4
Keyboard & Mouse	22	Accessories	17
Monitor	13	Monitor	7
Hard Drive	16	Hard Drive	8
Operating System	15	Software	16
Other Software	17	-	
Processor	33	Processor	10
Service	26	Service	39
Removable Storage	33	Storage	5
Multimedia	31	-	
I/O	35	-	
Cabinet	6	-	
		Reputation	35
		Reliability	14
		Warranty	12
		Delivery	6
		Discounts	5
		Upgrade	10
		Flexibility	10
		Cost & Payment	9
Other	20	Other	22
Total	286	Total	229

We have also provided you two grade scales which define the meanings of A, B, C, D, and F grades for each item in the absolute list and the relative list.

Please assign a grade to each item. We much appreciate your efforts as outside experts and we will be using the average of your scores to assign a numeric weight to each items that appears in a given groups report so we can get a quality scoring measure on the criteria established by each group.

If you have any questions contact us at njitexp@hotmail.com

We would hope to have your results by no later than the end of the first week of January.

Sincerely,

Zheng Li (zxl8078@njit.edu)
Yuanqiong Wang (yxw9836@njit.edu)

B.10.2 Scale for Absolute Criteria

SCALE FOR ABSOLUTE CRITERIA

A. A necessary minimum requirement valid in the past year and well representing a well specified statement of the requirement.

B A necessary minimum requirement valid in the past year but not the best possible statement of the requirement in the set of related statements you have.

C Should be a relative requirement not an absolute (maybe too expensive, and/or not of sufficient value relative to the other necessary requirements)

D Poorly states, incomplete, too low performance, or over specified as an absolute requirement

F Completely wrong, ambiguous, or meaningless.

B.10.3 Scale for Relative Criteria

SCALE FOR RELATIVE CRITERIA

A A nice-to-have feature valid in the past year and well representing a well specified statement of the requirement.

B A nice-to-have feature valid in the past year but not the best possible statement of the requirement in the set of related statements you have.

C Should be an absolute requirement not a relative (maybe a must have for today)

D Poorly states, incomplete, too low performance, or under specified as a relative requirement

F Completely wrong, ambiguous, or meaningless.

APPENDIX C

DATA ANALYSIS

In this appendix, the following data analysis results are presented:

C.1 Background Questionnaire Analysis

C.2 Frequency Counts on Criteria Ratings

C.3 Analysis on the Performance of Graduate Groups over Time

C.4 Inter-rater Reliability Test

C.5 Results Summary

Appendix C.1 Background Questionnaire Analysis

Table C1.1 Background Questionnaire Summary Table

Variable	Label	N	Range	Mean	Std dev	Skewness
BQ1	Confidence in recommending computer	185	4.00	0.71	0.91	-0.39
BQ2	Confidence in contributing in group	185	3.00	0.80	0.82	-0.39
BQ3	Computer Novice to Expert (1 2 3 4 5)	186	4.00	3.69	0.82	-0.55
BQ4	Group working experience	186	3.00	0.90	0.78	-0.02
BQ5	Business decision experience	186	4.00	0.24	0.97	-0.22
BQ6	Dislike group discussion	185	4.00	-0.81	0.96	0.74
BQ7	Nervous dealing with new people	186	4.00	-0.77	1.03	0.72
BQ8	WebBoard easy access	186	4.00	1.42	0.67	-1.51
BQ9	Comfortable group discussion	186	4.00	1.10	0.73	-1.00
Employ Month	EMPLOY_LENGTH	176	390.00	60.17	78.02	1.92

Table C1.2 Frequency Table on "Confidence in Recommending Computer"

BQ1	Frequency	Percent	Cumulative Frequency	Cumulative Percent
very low	2	1.08	2	1.08
low	15	8.11	17	9.19
medium	54	29.19	71	38.38
high	78	42.16	149	80.54
very high	36	19.46	185	100.00

Frequency Missing = 2

Table C1.3 Frequency Table on "Confidence in Contributing in Group"

BQ2	Frequency	Percent	Cumulative Frequency	Cumulative Percent
low	13	7.03	13	7.03
medium	45	24.32	58	31.35
high	93	50.27	151	81.62
very high	34	18.38	185	100.00

Frequency Missing = 2

Table C1.4 Frequency Table on "Computer Novice to Expert (1 2 3 4 5)"

BQ3	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Novice	2	1.08	2	1.08
2	12	6.45	14	7.53
3	52	27.96	66	35.48
4	95	51.08	161	86.56
Expert	25	13.44	186	100.00

Frequency Missing = 1

Table C1.5 Frequency Table on "Group Working Experience"

BQ4	Frequency	Percent	Cumulative Frequency	Cumulative Percent
low	3	1.61	3	1.61
medium	58	31.18	61	32.80
high	80	43.01	141	75.81
very high	45	24.19	186	100.00

Frequency Missing = 1

Table C1.6 Frequency Table on "Business Decision Experience"

BQ5	Frequency	Percent	Cumulative Frequency	Cumulative Percent
very low	8	4.30	8	4.30
low	30	16.13	38	20.43
medium	73	39.25	111	59.68
high	59	31.72	170	91.40
very high	16	8.60	186	100.00

Frequency Missing = 1

Table C1.7 Frequency Table on "Dislike Group Discussion"

BQ6	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Strongly Disagree	43	23.24	43	23.24
Disagree	88	47.57	131	70.81
Undecided	32	17.30	163	88.11
Agree	19	10.27	182	98.38
Strongly Agree	3	1.62	185	100.00

Frequency Missing = 2

Table C1.8 Frequency Table on "Nervous Dealing with New People"

BQ7	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Strongly Disagree	45	24.19	45	24.19
Disagree	87	46.77	132	70.97
Undecided	23	12.37	155	83.33
Agree	28	15.05	183	98.39
Strongly Agree	3	1.61	186	100.00

Frequency Missing = 1

Table C1.9 Frequency Table on "WebBoard Easy Access"

BQ8	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Strongly Disagree	1	0.54	1	0.54
Disagree	3	1.61	4	2.15
Undecided	4	2.15	8	4.30
Agree	86	46.24	94	50.54
Strongly Agree	92	49.46	186	100.00

Frequency Missing = 1

Table C1.10 Frequency Table on "Comfortable Group Discussion"

BQ9	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Strongly Disagree	1	0.54	1	0.54
Disagree	6	3.23	7	3.76
Undecided	17	9.14	24	12.90
Agree	112	60.22	136	73.12
Strongly Agree	50	26.88	186	100.00

Frequency Missing = 1

Table C1.11 Frequency Table on "Current Degree"

Current Degree	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Graduate Certificate	8	4.28	8	4.28
MBA	12	6.42	20	10.70
Other degrees	5	2.67	25	13.37
MS Telecommunications	1	0.53	26	13.90
MSCS	10	5.35	36	19.25
MSEM	2	1.07	38	20.32
MSIS	68	36.36	106	56.68
Ph.D.	14	7.49	120	64.17
Senior	34	18.18	154	82.35
On	30	16.04	184	98.40
bscs	1	0.53	185	98.93
Sophomore	2	1.07	187	100.00

Table C1.11 Frequency Table on "Under Major"

UNDER_MAJOR	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Other	74	39.57	74	39.57
Biochemistry	2	1.07	76	40.64
Biology	2	1.07	78	41.71
IT	3	1.60	81	43.32
MIS	2	1.07	83	44.39
Mathematics	2	1.07	85	45.45
ME	3	1.60	88	47.06
CS	52	27.81	140	74.87
BA/BM	1	0.53	141	75.40
IS	36	19.25	177	94.65
management	6	3.21	183	97.86
marketing	4	2.14	187	100.00

Table C1.12 Frequency Table on "Nationality"

NATIONALITY	Frequency	Percent	Cumulative Frequency	Cumulative Percent
AFRICAN	1	0.53	1	0.53
AMERICAN	63	33.69	64	34.22
AZERBAIJ	1	0.53	65	34.76
BANGLADE	1	0.53	66	35.29
BENGALI	1	0.53	67	35.83
BLACK	1	0.53	68	36.36
BRITISH	1	0.53	69	36.90
CHINESE	15	8.02	84	44.92
CIRCASSI	1	0.53	85	45.45
FILIPINO	4	2.14	89	47.59
GREEK	2	1.07	91	48.66
GUYANESE	3	1.60	94	50.27
HISPANIC	1	0.53	95	50.80
INDIAN	47	25.13	142	75.94
IRAN	1	0.53	143	76.47
IRISH	1	0.53	144	77.01
ITALIAN	2	1.07	146	78.07
JAMAICA	1	0.53	147	78.61
JORDANIA	1	0.53	148	79.14
KENYAN	2	1.07	150	80.21
KOREAN	3	1.60	153	81.82
MOROCCAN	1	0.53	154	82.35
NEW ZEAL	1	0.53	155	82.89
NIGERIAN	5	2.67	160	85.56
OTHER	1	0.53	161	86.10
PAKISTAN	4	2.14	165	88.24
POLISH	8	4.28	173	92.51
PORTUGUE	2	1.07	175	93.58
ROMANIAN	1	0.53	176	94.12
RUSSIAN	2	1.07	178	95.19
SLOVENIA	1	0.53	179	95.72
SOUTH KO	1	0.53	180	96.26
THAI	2	1.07	182	97.33
TRINIDAD	1	0.53	183	97.86
UKRAINIA	1	0.53	184	98.40
USONIAN	1	0.53	185	98.93
VIETNAME	2	1.07	187	100.00

Table C1.13 Frequency Table on "Ethnic Background"

ETHNIC_ BACKGROUND	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Asian	89	47.85	89	47.85
Black	19	10.22	108	58.06
Hispanic	4	2.15	112	60.22
Other	14	7.53	126	67.74
White	60	32.26	186	100.00

Frequency Missing = 1

Table C1.14 Frequency Table on "Gender"

GENDER	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Female	65	34.76	65	34.76
Male	122	65.24	187	100.00

Table C1.15 Frequency Table on "Age"

AGE	Frequency	Percent	Cumulative Frequency	Cumulative Percent
23-30	94	50.54	94	50.54
31-40	32	17.20	126	67.74
over 40	10	5.38	136	73.12
under 23	50	26.88	186	100.00

Frequency Missing = 1

Table C1.16 Frequency Table on "English as First Language"

ENGLISH	Frequency	Percent Cumulative	Frequency	Cumulative Percent
N	100	53.76	100	53.76
Y	86	46.24	186	100.00

Frequency Missing = 1

Table C1.17 Frequency Table on "the Number of Years You have Lived in the US"

BORN_YEARS	Frequency	Percent	Cumulative Frequency	Cumulative Percent
born in US	86	48.04	86	48.04
0	2	1.12	88	49.16
0.5	1	0.56	89	49.72
1 year	8	4.47	97	54.19
1 year, 2	1	0.56	98	54.75
1.3	1	0.56	99	55.31
1.5 years	2	1.12	101	56.42
10 years	8	4.47	109	60.89
11 years	8	4.47	117	65.36
12	1	0.56	118	65.92
13	2	1.12	120	67.04
14	1	0.56	121	67.60
14 and a h	1	0.56	122	68.16
15	3	1.68	125	69.83
16	1	0.56	126	70.39
2 years	5	2.79	131	73.18
2.5	1	0.56	132	73.74
20 years	1	0.56	133	74.30
21 years	1	0.56	134	74.86
23	1	0.56	135	75.42
27	2	1.12	137	76.54
3	6	3.35	143	79.89
3.5	1	0.56	144	80.45
3years 7mo	1	0.56	145	81.01
4 years	3	1.68	148	82.68
4 YEARS &	1	0.56	149	83.24
4.5	1	0.56	150	83.80
5 years	7	3.91	157	87.71
5years & 6	1	0.56	158	88.27
6 years	4	2.23	162	90.50
7 years	5	2.79	167	93.30
7 months	2	1.12	169	94.41
8 years	2	1.12	171	95.53
9 years	5	2.79	176	98.32
almost 3 y	1	0.56	177	98.88
india	1	0.56	178	99.44
<1 year	1	0.56	179	100.00

Frequency Missing = 8

Table C1.18 Frequency Table on "Fulltime Employment Length"

EMPLOY LENGTH	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	29	16.48	29	16.48
1	1	0.57	30	17.05
2	2	1.14	32	18.18
3	5	2.84	37	21.02
4	2	1.14	39	22.16
5	4	2.27	43	24.43
6	4	2.27	47	26.70
7	1	0.57	48	27.27
8	3	1.70	51	28.98
9	4	2.27	55	31.25
10	4	2.27	59	33.52
12	6	3.41	65	36.93
15	3	1.70	68	38.64
16	1	0.57	69	39.20
18	2	1.14	71	40.34
20	3	1.70	74	42.05
21	1	0.57	75	42.61
22	1	0.57	76	43.18
24	8	4.55	84	47.73
26	1	0.57	85	48.30
29	1	0.57	86	48.86
30	4	2.27	90	51.14
31	1	0.57	91	51.70
36	12	6.82	103	58.52
42	1	0.57	104	59.09
45	1	0.57	105	59.66
46	1	0.57	106	60.23
48	4	2.27	110	62.50
50	2	1.14	112	63.64
54	2	1.14	114	64.77
55	1	0.57	115	65.34
58	1	0.57	116	65.91
60	7	3.98	123	69.89
65	1	0.57	124	70.45
72	5	2.84	129	73.30
74	1	0.57	130	73.86
75	1	0.57	131	74.43
82	1	0.57	132	75.00
84	2	1.14	134	76.14
90	1	0.57	135	76.70
91	1	0.57	136	77.27
96	4	2.27	140	79.55
108	3	1.70	143	81.25
120	6	3.41	149	84.66
132	2	1.14	151	85.80
133	1	0.57	152	86.36
144	2	1.14	154	87.50
168	2	1.14	156	88.64
180	2	1.14	158	89.77
190	1	0.57	159	90.34
192	3	1.70	162	92.05

EMPLOY LENGTH	Frequency	Percent	Cumulative Frequency	Cumulative Percent
200	1	0.57	163	92.61
204	3	1.70	166	94.32
210	1	0.57	167	94.89
228	1	0.57	168	95.45
240	1	0.57	169	96.02
255	1	0.57	170	96.59
260	2	1.14	172	97.73
288	1	0.57	173	98.30
336	1	0.57	174	98.86
384	1	0.57	175	99.43
390	1	0.57	176	100.00

Frequency Missing = 11

Table C1.19 Frequency Table on "Have Bought a Computer before"

BOUGHT	Frequency	Percent Cumulative	Frequency	Cumulative Percent
No	11	5.88	11	5.88
Yes	176	94.12	187	100.00

Table C1.20 Frequency Table on "Bought for"

BOUGHT_FOR	Frequency	Percent	Cumulative Frequency	Cumulative Percent
myself	124	70.45	124	70.45
myself,organization	30	17.05	154	87.50
myself,organization,other	13	7.39	167	94.89
myself,other	5	2.84	172	97.73
organization	3	1.70	175	99.43
organization,other	1	0.57	176	100.00

Frequency Missing = 11

Table C1.21 Frequency Table on "Bought Times"

BOUGHT TIMES	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Once	60	34.29	144	82.29
Twice	31	17.71	175	100.00
More than two times	84	48.00	84	48.00

Frequency Missing = 12

Appendix C.2 Frequency Counts on Criteria Ratings

C.2.1 Frequency Counts on Absolute Ratings

The scale for absolute criteria: A=4, B=3, C=2, D=1, F=0

A. A necessary minimum requirement valid in the past year and well representing a well specified statement of the requirement.

B A necessary minimum requirement valid in the past year but not the best possible statement of the requirement in the set of related statements you have.

C Should be a relative requirement not an absolute (maybe too expensive, and/or not of sufficient value relative to the other necessary requirements)

D Poorly states, incomplete, too low performance, or over specified as an absolute requirement

F Completely wrong, ambiguous, or meaningless.

Overall

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	326	19.11	326	19.11
1	384	22.51	710	41.62
2	390	22.86	1100	64.48
3	266	15.59	1366	80.07
4	340	19.93	1706	100.00

Frequency Missing = 58

By Degree

Graduate

Rating	Frequency	Percent
0	211	18.84
1	255	22.77
2	249	22.23
3	172	15.36
4	233	20.80

Frequency Missing = 40

Undergraduate

Rating	Frequency	Percent
0	115	19.62
1	129	22.01
2	141	24.06
3	94	16.04
4	107	18.26

Frequency Missing = 18

By Tool Condition

Voting Process		LIST GATHERING PROCESS: With List Gathering Tool Support			LIST GATHERING PROCESS: Manual		
		Rating	Frequency	Percent	Rating	Frequency	Percent
With HDV Tool Support		0	85	20.83	0	57	15.62
		1	102	25.00	1	93	25.48
		2	80	19.61	2	76	20.82
		3	56	13.73	3	65	17.81
		4	85	20.83	4	74	20.27
		Frequency Missing = 12			Frequency Missing = 11		
Manual		Rating	Frequency	Percent	Rating	Frequency	Percent
		0	79	20.52	0	105	19.16
		1	76	19.74	1	113	20.62
		2	93	24.16	2	141	25.73
		3	65	16.88	3	80	14.60
		4	72	18.70	4	109	19.89
		Frequency Missing = 11			Frequency Missing = 24		

ListTool X VotingTool X Degree

Graduate

Voting Process		LIST GATHERING PROCESS: With List Gathering Tool Support			LIST GATHERING PROCESS: Manual		
		Rating	Frequency	Percent	Rating	Frequency	Percent
With HDV Tool Support		0	43	19.63	0	34	16.92
		1	56	25.57	1	51	25.37
		2	40	18.26	2	45	22.39
		3	27	12.33	3	34	16.92
		4	53	24.20	4	37	18.41
		Frequency Missing = 5			Frequency Missing = 7		
Manual		Rating	Frequency	Percent	Rating	Frequency	Percent
		0	47	18.01	0	87	19.82
		1	51	19.54	1	97	22.10
		2	61	23.37	2	103	23.46
		3	51	19.54	3	60	13.67
		4	51	19.54	4	92	20.96
		Frequency Missing = 7			Frequency Missing = 21		

Under		LIST GATHERING PROCESS					
		With List Gathering Tool Support			Manual		
Voting Process		Rating	Frequency	Percent	Rating	Frequency	Percent
	With HDV Tool Support	0	42	22.22	0	23	14.02
		1	46	24.34	1	42	25.61
		2	40	21.16	2	31	18.90
		3	29	15.34	3	31	18.90
		4	32	16.93	4	37	22.56
		Frequency Missing = 7			Frequency Missing = 4		
		Rating	Frequency	Percent	Rating	Frequency	Percent
	Manual	0	32	25.81	0	18	16.51
		1	25	20.16	1	16	14.68
		2	32	25.81	2	38	34.86
		3	14	11.29	3	20	18.35
		4	21	16.94	4	17	15.60
		Frequency Missing = 4			Frequency Missing = 3		

------------------------------- GID=GLN01 --------------------------

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	8	13.56	8	13.56
1	15	25.42	23	38.98
2	10	16.95	33	55.93
3	13	22.03	46	77.97
4	13	22.03	59	100.00

Frequency Missing = 1

-- GID=GLN02 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	13	22.81	13	22.81
1	13	22.81	26	45.61
2	14	24.56	40	70.18
3	10	17.54	50	87.72
4	7	12.28	57	100.00

Frequency Missing = 3

-- GID=GLN03 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	11	14.67	11	14.67
1	12	16.00	23	30.67
2	18	24.00	41	54.67
3	18	24.00	59	78.67
4	16	21.33	75	100.00

Frequency Missing = 1

---------- GID=GLN04 ----------

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	1	9.09	1	9.09
1	1	9.09	2	18.18
2	7	63.64	9	81.82
3	1	9.09	10	90.91
4	1	9.09	11	100.00

Frequency Missing = 1

---------- GID=GLN05 ----------

Rating	Frequency	Percent Cumulative	Frequency	Cumulative Percent
0	14	23.73	14	23.73
1	10	16.95	24	40.68
2	12	20.34	36	61.02
3	9	15.25	45	76.27
4	14	23.73	59	100.00

Frequency Missing = 1

---------- GID=GLN10 ----------

Rating	Frequency	Percent Cumulative	Frequency	Cumulative Percent
0	7	23.33	7	23.33
1	4	13.33	11	36.67
2	12	40.00	23	76.67
4	7	23.33	30	100.00

Frequency Missing = 2

---------- GID=GLN11 ----------

Rating	Frequency	Percent Cumulative	Frequency	Cumulative Percent
0	17	30.91	17	30.91
1	14	25.45	31	56.36
2	10	18.18	41	74.55
3	6	10.91	47	85.45
4	8	14.55	55	100.00

Frequency Missing = 1

---------- GID=GLN12 ----------

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	8	20.51	8	20.51
1	7	17.95	15	38.46
2	10	25.64	25	64.10
3	8	20.51	33	84.62
4	6	15.38	39	100.00

Frequency Missing = 1

---------- GID=GLV01 ----------

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	11	20.00	11	20.00
1	15	27.27	26	47.27
2	9	16.36	35	63.64
3	5	9.09	40	72.73
4	15	27.27	55	100.00

Frequency Missing = 1

-- GID=GLV02 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	13	24.07	13	24.07
1	15	27.78	28	51.85
2	12	22.22	40	74.07
3	7	12.96	47	87.04
4	7	12.96	54	100.00

Frequency Missing = 2

-- GID=GLV05 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	6	12.77	6	12.77
1	8	17.02	14	29.79
2	11	23.40	25	53.19
3	7	14.89	32	68.09
4	15	31.91	47	100.00

Frequency Missing = 1

-- GID=GLV06 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	13	20.63	13	20.63
1	18	28.57	31	49.21
2	8	12.70	39	61.90
3	8	12.70	47	74.60
4	16	25.40	63	100.00

Frequency Missing = 1

-- GID=GLV10 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	10	20.83	10	20.83
1	15	31.25	25	52.08
2	7	14.58	32	66.67
3	6	12.50	38	79.17
4	10	20.83	48	100.00

-- GID=GLV11 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	15	21.43	15	21.43
1	12	17.14	27	38.57
2	14	20.00	41	58.57
3	14	20.00	55	78.57
4	15	21.43	70	100.00

Frequency Missing = 2

-- GID=GLV12 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	10	24.39	10	24.39
1	10	24.39	20	48.78
2	11	26.83	31	75.61
3	4	9.76	35	85.37
4	6	14.63	41	100.00

Frequency Missing = 3

GID=GLV13

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	7	23.33	7	23.33
1	9	30.00	16	53.33
2	8	26.67	24	80.00
3	5	16.67	29	96.67
4	1	3.33	30	100.00

Frequency Missing = 2

GID=GNN01

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	14	18.42	14	18.42
1	16	21.05	30	39.47
2	17	22.37	47	61.84
3	10	13.16	57	75.00
4	19	25.00	76	100.00

Frequency Missing = 4

GID=GNN02

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	12	20.34	12	20.34
1	11	18.64	23	38.98
2	12	20.34	35	59.32
3	12	20.34	47	79.66
4	12	20.34	59	100.00

Frequency Missing = 1

GID=GNN03

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	2	6.06	2	6.06
1	7	21.21	9	27.27
2	10	30.30	19	57.58
3	9	27.27	28	84.85
4	5	15.15	33	100.00

Frequency Missing = 3

GID=GNN04

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	20	23.81	20	23.81
1	22	26.19	42	50.00
2	14	16.67	56	66.67
3	12	14.29	68	80.95
4	16	19.05	84	100.00

Frequency Missing = 4

GID=GNN05

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	7	11.29	7	11.29
1	8	12.90	15	24.19
2	20	32.26	35	56.45
3	7	11.29	42	67.74
4	20	32.26	62	100.00

Frequency Missing = 6

-- GID=GNN06 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	12	21.05	12	21.05
1	13	22.81	25	43.86
2	14	24.56	39	68.42
3	7	12.28	46	80.70
4	11	19.30	57	100.00

Frequency Missing = 3

-- GID=GNN07 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	20	29.41	20	29.41
1	20	29.41	40	58.82
2	16	23.53	56	82.35
3	3	4.41	59	86.76
4	9	13.24	68	100.00

-- GID=GNN10 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	6	9.52	6	9.52
1	8	12.70	14	22.22
2	24	38.10	38	60.32
3	13	20.63	51	80.95
4	12	19.05	63	100.00

Frequency Missing = 1

-- GID=GNN11 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	12	26.09	12	26.09
1	8	17.39	20	43.48
2	14	30.43	34	73.91
3	7	15.22	41	89.13
4	5	10.87	46	100.00

Frequency Missing = 2

-- GID=GNV02 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	8	17.78	8	17.78
1	12	26.67	20	44.44
2	11	24.44	31	68.89
3	7	15.56	38	84.44
4	7	15.56	45	100.00

Frequency Missing = 3

-- GID=GNV04 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	8	14.04	8	14.04
1	12	21.05	20	35.09
2	13	22.81	33	57.89
3	10	17.54	43	75.44
4	14	24.56	57	100.00

Frequency Missing = 3

-- GID=GNV06 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	14	22.22	14	22.22
1	15	23.81	29	46.03
2	10	15.87	39	61.90
3	9	14.29	48	76.19
4	15	23.81	63	100.00

Frequency Missing = 1

-- GID=GNV07 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	4	11.11	4	11.11
1	12	33.33	16	44.44
2	11	30.56	27	75.00
3	8	22.22	35	97.22
4	1	2.78	36	100.00

-- GID=GNV10 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	7	16.28	7	16.28
1	15	34.88	22	51.16
2	8	18.60	30	69.77
3	4	9.30	34	79.07
4	9	20.93	43	100.00

Frequency Missing = 1

-- GID=GNV11 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	7	13.73	7	13.73
1	11	21.57	18	35.29
2	12	23.53	30	58.82
3	11	21.57	41	80.39
4	10	19.61	51	100.00

Frequency Missing = 1

-- GID=GNV12 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	3	9.38	3	9.38
1	5	15.63	8	25.00
2	5	15.63	13	40.63
3	10	31.25	23	71.88
4	9	28.13	32	100.00

-- GID=GNV13 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	6	15.79	6	15.79
1	11	28.95	17	44.74
2	6	15.79	23	60.53
3	6	15.79	29	76.32
4	9	23.68	38	100.00

Frequency Missing = 2

C.2.2 Frequency Counts on Relative Ratings

The scale for relative criteria: A=4, B=3, C=2, D=1, F=0

- A A nice-to-have feature valid in the past year and well representing a well specified statement of the requirement.
- B A nice-to-have feature valid in the past year but not the best possible statement of the requirement in the set of related statements you have.
- C Should be an absolute requirement not a relative (maybe a must have for today)
- D Poorly states, incomplete, too low performance, or under specified as a relative requirement
- F Completely wrong, ambiguous, or meaningless.

Overall

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	110	10.13	110	10.13
1	306	28.18	416	38.31
1.5	1	0.09	417	38.40
2	195	17.96	612	56.35
2.5	3	0.28	615	56.63
3	271	24.95	886	81.58
3.5	3	0.28	889	81.86
4	197	18.14	1086	100.00

Frequency Missing = 42

By Degree

Graduate			Undergraduate		
Rating	Frequency	Percent	Rating	Frequency	Percent
0	68	9.09	0	42	12.43
1	212	28.34	1	94	27.81
2	142	18.98	1.5	1	0.30
2.5	2	0.27	2	53	15.68
3	189	25.27	2.5	1	0.30
3.5	2	0.27	3	82	24.26
4	133	17.78	3.5	1	0.30
			4	64	18.93
Frequency Missing = 24			Frequency Missing = 18		

By Tool Condition

		LIST GATHERING PROCESS					
		With List Gathering Tool Support			**Manual**		
Voting Process		**Rating**	**Frequency**	**Percent**	**Rating**	**Frequency**	**Percent**
	With HDV Tool Support	0	42	15.38	0	23	9.06
		1	84	30.77	1	74	29.13
		2	45	16.48	1.5	1	0.39
		3	60	21.98	2	39	15.35
		3.5	3	1.10	2.5	1	0.39
		4	39	14.29	3	79	31.10
					4	37	14.57
		Frequency Missing = 3			Frequency Missing = 10		
	Manual	**Rating**	**Frequency**	**Percent**	**Rating**	**Frequency**	**Percent**
		0	12	7.69	0	33	8.19
		1	41	26.28	1	107	26.55
		2	33	21.15	2	78	19.35
		3	39	25.00	2.5	2	0.50
		4	31	19.87	3	93	23.08
					4	90	22.33
		Frequency Missing = 16			Frequency Missing = 13		

ListTool X VotingTool X Degree

Graduate		LIST GATHERING PROCESS					
		With List Gathering Tool Support			**Manual**		
Voting Process		**Rating**	**Frequency**	**Percent**	**Rating**	**Frequency**	**Percent**
	With HDV Tool Support	0	14	10.29	0	18	11.04
		1	49	36.03	1	43	26.38
		2	20	14.71	2	27	16.56
		3	31	22.79	3	55	33.74
		3.5	2	1.47	4	20	12.27
		4	20	14.71	Frequency Missing = 9		
	Manual	**Rating**	**Frequency**	**Percent**	**Rating**	**Frequency**	**Percent**
		0	7	6.31	0	29	8.58
		1	30	27.03	1	90	26.63
		2	25	22.52	2	70	20.71
		3	29	26.13	2.5	2	0.59
		4	20	18.02	3	74	21.89
					4	73	21.60
		Frequency Missing = 5			Frequency Missing = 10		

UNDER		LIST GATHERING PROCESS					
		With List Gathering Tool Support			Manual		
Voting Process		Rating	Frequency	Percent	Rating	Frequency	Percent
	With HDV Tool Support	0	28	20.44	0	5	5.49
		1	35	25.55	1	31	34.07
		2	25	18.25	1.5	1	1.10
		3	29	21.17	2	12	13.19
		3.5	1	0.73	2.5	1	1.10
		4	19	13.87	3	24	26.37
					4	17	18.68
		Frequency Missing = 3			Frequency Missing = 1		
	Manual	Rating	Frequency	Percent	Rating	Frequency	Percent
		0	5	11.11	0	4	6.15
		1	11	24.44	1	17	26.15
		2	8	17.78	2	8	12.31
		3	10	22.22	3	19	29.23
		4	11	24.44	4	17	26.15
		Frequency Missing = 11			Frequency Missing = 3		

--- GID=GLN01 ---

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	1	5.00	1	5.00
1	5	25.00	6	30.00
2	3	15.00	9	45.00
3	6	30.00	15	75.00
4	5	25.00	20	100.00

--- GID=GLN02 ---

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
1	3	16.67	3	16.67
2	3	16.67	6	33.33
3	4	22.22	10	55.56
4	8	44.44	18	100.00

Frequency Missing = 2

-- GID=GLN03 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	1	4.35	1	4.35
1	1	4.35	2	8.70
2	9	39.13	11	47.83
3	10	43.48	21	91.30
4	2	8.70	23	100.00

Frequency Missing = 1

-- GID=GLN04 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	2	10.00	2	10.00
1	8	40.00	10	50.00
2	5	25.00	15	75.00
3	4	20.00	19	95.00
4	1	5.00	20	100.00

-- GID=GLN05 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	3	10.00	3	10.00
1	13	43.33	16	53.33
2	5	16.67	21	70.00
3	5	16.67	26	86.67
4	4	13.33	30	100.00

Frequency Missing = 2

-- GID=GLN10 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	4	26.67	4	26.67
1	2	13.33	6	40.00
2	4	26.67	10	66.67
3	3	20.00	13	86.67
4	2	13.33	15	100.00

Frequency Missing = 5

-- GID=GLN11 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
3	4	44.44	4	44.44
4	5	55.56	9	100.00

Frequency Missing = 3

-- GID=GLN12 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	1	4.76	1	4.76
1	9	42.86	10	47.62
2	4	19.05	14	66.67
3	3	14.29	17	80.95
4	4	19.05	21	100.00

Frequency Missing = 3

GID=GLV01

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	2	8.33	2	8.33
1	8	33.33	10	41.67
2	4	16.67	14	58.33
3	6	25.00	20	83.33
3.5	1	4.17	21	87.50
4	3	12.50	24	100.00

GID=GLV02

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	4	12.50	4	12.50
1	13	40.63	17	53.13
2	4	12.50	21	65.63
3	8	25.00	29	90.63
3.5	1	3.13	30	93.75
4	2	6.25	32	100.00

GID=GLV05

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	4	8.33	4	8.33
1	18	37.50	22	45.83
2	5	10.42	27	56.25
3	11	22.92	38	79.17
4	10	20.83	48	100.00

GID=GLV06

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	4	12.50	4	12.50
1	10	31.25	14	43.75
2	7	21.88	21	65.63
3	6	18.75	27	84.38
4	5	15.63	32	100.00

GID=GLV10

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	4	11.43	4	11.43
1	9	25.71	13	37.14
2	7	20.00	20	57.14
3	12	34.29	32	91.43
4	3	8.57	35	100.00

Frequency Missing = 1

GID=GLV11

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	11	31.43	11	31.43
1	7	20.00	18	51.43
2	6	17.14	24	68.57
3	6	17.14	30	85.71
4	5	14.29	35	100.00

Frequency Missing = 1

-- GID=GLV12 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	12	25.53	12	25.53
1	12	25.53	24	51.06
2	7	14.89	31	65.96
3	8	17.02	39	82.98
4	8	17.02	47	100.00

Frequency Missing = 1

-- GID=GLV13 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	1	5.00	1	5.00
1	7	35.00	8	40.00
2	5	25.00	13	65.00
3	3	15.00	16	80.00
3.5	1	5.00	17	85.00
4	3	15.00	20	100.00

-- GID=GNN01 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	1	1.67	1	1.67
1	13	21.67	14	23.33
2	13	21.67	27	45.00
2.5	1	1.67	28	46.67
3	11	18.33	39	65.00
4	21	35.00	60	100.00

-- GID=GNN02 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	5	11.63	5	11.63
1	7	16.28	12	27.91
2	9	20.93	21	48.84
3	19	44.19	40	93.02
4	3	6.98	43	100.00

Frequency Missing = 1

-- GID=GNN03 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
1	6	25.00	6	25.00
2	9	37.50	15	62.50
2.5	1	4.17	16	66.67
3	1	4.17	17	70.83
4	7	29.17	24	100.00

-- GID=GNN04 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	3	4.69	3	4.69
1	15	23.44	18	28.13
2	13	20.31	31	48.44
3	16	25.00	47	73.44
4	17	26.56	64	100.00

-- GID=GNN05 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	11	17.19	11	17.19
1	13	20.31	24	37.50
2	9	14.06	33	51.56
3	17	26.56	50	78.13
4	14	21.88	64	100.00

Frequency Missing = 4

-- GID=GNN06 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	4	11.76	4	11.76
1	13	38.24	17	50.00
2	6	17.65	23	67.65
3	5	14.71	28	82.35
4	6	17.65	34	100.00

Frequency Missing = 2

-- GID=GNN07 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	5	10.20	5	10.20
1	23	46.94	28	57.14
2	11	22.45	39	79.59
3	5	10.20	44	89.80
4	5	10.20	49	100.00

Frequency Missing = 3

-- GID=GNN10 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
1	10	33.33	10	33.33
2	2	6.67	12	40.00
3	9	30.00	21	70.00
4	9	30.00	30	100.00

Frequency Missing = 2

-- GID=GNN11 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	4	11.43	4	11.43
1	7	20.00	11	31.43
2	6	17.14	17	48.57
3	10	28.57	27	77.14
4	8	22.86	35	100.00

Frequency Missing = 1

-- GID=GNV02 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	6	15.38	6	15.38
1	9	23.08	15	38.46
2	7	17.95	22	56.41
3	14	35.90	36	92.31
4	3	7.69	39	100.00

Frequency Missing = 1

-- GID=GNV04 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	5	14.29	5	14.29
1	8	22.86	13	37.14
2	5	14.29	18	51.43
3	13	37.14	31	88.57
4	4	11.43	35	100.00

Frequency Missing = 1

-- GID=GNV06 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	4	8.33	4	8.33
1	14	29.17	18	37.50
2	11	22.92	29	60.42
3	16	33.33	45	93.75
4	3	6.25	48	100.00

Frequency Missing = 4

-- GID=GNV07 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	3	7.32	3	7.32
1	12	29.27	15	36.59
2	4	9.76	19	46.34
3	12	29.27	31	75.61
4	10	24.39	41	100.00

Frequency Missing = 3

-- GID=GNV10 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	1	6.67	1	6.67
1	5	33.33	6	40.00
2.5	1	6.67	7	46.67
3	5	33.33	12	80.00
4	3	20.00	15	100.00

Frequency Missing = 1

-- GID=GNV11 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	4	7.14	4	7.14
1	18	32.14	22	39.29
1.5	1	1.79	23	41.07
2	6	10.71	29	51.79
3	17	30.36	46	82.14
4	10	17.86	56	100.00

-- GID=GNV12 --

Rating	Frequency	Percent	Cumulative Frequency	Cumulative Percent
1	8	40.00	8	40.00
2	6	30.00	14	70.00
3	2	10.00	16	80.00
4	4	20.00	20	100.00

Appendix C.3 Analysis on the Performance of Graduate Groups over Time (Based on Group Reports)

The original data was not normally distributed:

Parameter	Estimate
Mean	52.73864
Std Dev	13.50936

Goodness-of-Fit Tests for Normal Distribution

Test	---Statistic----		-----p Value-----	
Kolmogorov-Smirnov	D	0.17150021	Pr > D	<0.010
Cramer-von Mises	W-Sq	0.22832247	Pr > W-Sq	<0.005
Anderson-Darling	A-Sq	1.38594140	Pr > A-Sq	<0.005

After data transformation using square, the data is normally distributed.

Parameter	Estimate
Mean	2959.304
Std Dev	1252.953

Goodness-of-Fit Tests for Normal Distribution

Test	---Statistic----		-----p Value-----	
Kolmogorov-Smirnov	D	0.11192916	Pr > D	>0.150
Cramer-von Mises	W-Sq	0.08548735	Pr > W-Sq	0.176
Anderson-Darling	A-Sq	0.55381927	Pr > A-Sq	0.147

One-way ANOVA shows that groups participated in the experiment earlier (Spring 2002) did significantly better than groups participated in the later session (Fall 2002). Therefore, the significant difference on the quality of group reports based on the whole data set (including both graduate and undergraduate groups) should not be interpreted as the effect of the tools only. The different time period also played a role here (at least for graduate groups).

The mean value in the table below shows the result after data transformation.

Means

Time	Performance	Std. Dev.
Spring 2002	3672.42	685.19
Fall 2002	2575.32	1329.20
	2959.30	1252.95

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	10953053.26	10953053.26	8.28	0.0065
Error	38	50272655.84	1322964.63		
Corrected Total	39	61225709.10			

Source	DF	SS	Mean Square	F Value	Pr > F
Time	1	10953053.26	10953053.26	8.28	**0.0065**

Appendix C.4 Inter-rater Reliability Test

Below is the result on the inter-rater reliability based on the ratings for criteria list. Four people from Computer Service Department in NJIT served as experts to give grade on each criterion on the lists. It is obvious that there are big differences among ratings from different expert. The data analysis below also indicates that the inter-rater reliability is very low (the highest correlation for absolute criteria list is 0.47, and 0.28 for relative criteria list).

Inter-rater reliability (Relative Criteria List)

The scale for relative criteria: A=4, B=3, C=2, D=1, F=0

A A nice-to-have feature valid in the past year and well representing a well specified statement of the requirement.

B A nice-to-have feature valid in the past year but not the best possible statement of the requirement in the set of related statements you have.

C Should be an absolute requirement not a relative (maybe a must have for today)

D Poorly states, incomplete, too low performance, or under specified as a relative requirement

F Completely wrong, ambiguous, or meaningless.

Simple Statistics

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
Rater1	276	2.46739	1.57099	681.00000	0	4.00000
Rater2	256	1.69141	0.95511	433.00000	0	4.00000
Rater3	280	1.81071	1.23707	507.00000	0	4.00000
Rater4	274	2.53832	1.04889	695.50000	0	4.00000

Pearson Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	Rater1	Rater2	Rater3	Rater4
Rater1	1.00000	-0.03203	0.02781	0.03968
Rater1		0.6136	0.6467	0.5178
	276	251	274	268
Rater2	-0.03203	1.00000	0.27677	0.07631
Rater2	0.6136		<.0001	0.2302
	251	256	254	249
Rater3	0.02781	0.27677	1.00000	0.00818
Rater3	0.6467	<.0001		0.8930
	274	254	280	273
Rater4	0.03968	0.07631	0.00818	1.00000
Rater4	0.5178	0.2302	0.8930	
	268	249	273	274

Inter-rater reliability (Absolute Criteria List)

The scale for absolute criteria: A=4, B=3, C=2, D=1, F=0

A. A necessary minimum requirement valid in the past year and well representing a well specified statement of the requirement.

B A necessary minimum requirement valid in the past year but not the best possible statement of the requirement in the set of related statements you have.

C Should be a relative requirement not an absolute (maybe too expensive, and/or not of sufficient value relative to the other necessary requirements)

D Poorly states, incomplete, too low performance, or over specified as an absolute requirement

F Completely wrong, ambiguous, or meaningless.

Simple Statistics

Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
Rater1	415	2.15	1.67	894.00	0	4
Rater2	419	2.73	0.96	1145.00	0	4
Rater3	432	1.29	0.99	558.00	0	4
Rater4	440	1.65	1.39	725.00	0	4

Pearson Correlation Coefficients
Prob > |r| under H0: Rho=0
Number of Observations

	Rater1	Rater2	Rater3	Rater4
Rater1	1.00000	0.11803	-0.01324	0.19039
Rater1		0.0191	0.7902	<.0001
	415	394	406	414
Rater2	0.11803	1.00000	0.08059	0.04133
Rater2	0.0191		0.1007	0.3993
	394	419	416	418
Rater3	-0.01324	0.08059	1.00000	0.47329
Rater3	0.7902	0.1007		<.0001
	406	416	432	431
Rater4	0.19039	0.04133	0.47329	1.00000
Rater4	<.0001	0.3993	<.0001	
	414	418	431	440

Appendix C.5 Summary of Results

Hypothesis/Research Question	Result
H1. Groups supported by tools, compared to groups not supported by tools (manual groups), will have higher perceived quality of decision-making.	Not supported
H1a. Groups supported by the list gathering tool, compared to groups not supported by the list gathering tool, will have higher perceived quality of decision-making.	Not supported
H1b. Groups supported by both the list gathering and the voting tools will have the highest perceived quality of decision-making.	Not supported
H2. Groups with tool support, compared to groups without tool support (manual groups), will have a higher level of understanding of the task.	Not supported
H2a. Groups with the list gathering tool support, compared to groups without the list gathering tool support, will have a higher level of understanding of the task.	*Only supported on the analysis on the ability to discover valid alternatives*
H2b. Groups with both the list gathering and the voting tool support will have the highest level of understanding of the task.	*Only supported on the analysis on the ability to discover valid alternatives*
H3. Groups with tool support, compared to groups without tool support (manual groups), will have lower levels of information overload.	Not supported
H3a. Groups with the list gathering tool support, compared to groups without the list gathering tool support, will have lower levels of information overload.	Not supported
H3b. Groups with both the list gathering and the voting tool support will have the lowest level of information overload.	Not supported
H4. Groups with tool support, compared to groups without tool support (manual groups), will be more satisfied with their solutions.	Not supported
H4a. Groups with the list gathering tool support, compared to groups without the list gathering tool support, will be more satisfied with their solutions.	*Only supported for graduate student groups*
H4b. Groups with both the list-gathering and the voting tool support will be the most satisfied with their solutions.	Not supported
H5. Groups with tool support, compared to groups without tool support (manual groups), will report higher level of satisfaction with their group process.	Not supported
H5a. Groups with the list gathering tool support, compared to groups without the list gathering tool support, will report higher level of satisfaction with their group process.	Not supported

Hypothesis/Research Question	Result
H5b. Groups with both the list-gathering and the voting tool support will report the highest level of satisfaction with their group process.	Not supported
H6. Groups with tool support, compared to groups without tool support (manual groups), will have higher quality of decision-making.	Report: Not supported Criteria: Not supported (<u>NoVTool > VTool</u>) *Graduate > Undergraduate*
H6a. Groups with list gathering tool support, compared to groups without list gathering tool support, will have higher quality of decision-making.	Not supported Report: <u>LTool < NoLTool</u> Absolute Criteria: <u>Under NoLTool> All Others</u> Relative Criteria: No significant effect
H6b. Groups with both list gathering and voting tool support will have the highest quality of decision-making.	Not supported Report: <u>LV < NN</u> Absolute Criteria: No significant effect Relative Criteria: No significant effect
Research Question: length of comments	*VTool < NoVTool* *Coordinator > Member* *Graduate > Undergraduate* *Graduate Coordinator (Most)* *Undergraduate Member (Least)* *Graduate: List < NoList* *VTool Under (Least)* *Manual Coordinator (Most)*
Equality of participation	No significant difference
The effort required to carry out task	Undergraduate > Graduate No support highest

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