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The impacts of Delphi communication structure on small and medium sized asynchronous virtual teams

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ABSTRACT

THE IMPACTS OF DELPHI COMMUNICATION STRUCTURE ON SMALL AND MEDIUM SIZED ASYNCHRONOUS VIRTUAL TEAMS

by
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The improvement of Internet technology has motivated distributed work groups to collaborate without meeting face to face. Although asynchronous meetings through Web-based group communications systems enable groups dispersed temporarily and geographically to collaborate more flexibly, parallel and non-linear communication among dispersed members also challenge effective and efficient group coordination. Moreover, the Web-based asynchronous meeting is distinguished not only from the face-to-face meeting but also from the synchronous computer-supported meeting in terms of coordination process. However, previous asynchronous group communications or virtual team research focused more on the comparison of this new type of meeting with the face-to-face meeting. Not many research efforts have been exerted to improve the productivity of this new form of meeting and find ways to overcome its disadvantages. Facilitation was proved effective to enhance the productivity of synchronous meetings. However the effect of structured discussion through facilitation was not clear in asynchronous meeting settings even though facilitation is a common practice in asynchronous group communication systems.

This study examined the effect of a facilitated structure in improving the productivity of asynchronous decision-making groups. Delphi was chosen as the facilitated structure because it has been widely used as the paper-and-pencil-based structure to facilitate dispersed experts in collecting their opinions. In this study a computer-based Delphi structure was implemented through asynchronous Computer-Mediated Communication. A 2X2 controlled experiment was conducted to investigate the effect of Delphi structure on the effectiveness of small-sized (5-6 members) and medium-sized (10-12 members) asynchronous computer-supported groups. The formal facilitation using Delphi structure was effective to improve the productivity of asynchronous groups in generating more ideas. On the contrary, informal leadership by group coordinators seems to have played a more important role in producing better reports. In terms of per person ideas, small-sized groups were more productive, even though medium-sized groups produced more total ideas than small-sized groups. The superiority of Delphi groups and small-sized groups is related to their higher equality of participation. This result suggests that in asynchronous meetings, equal participation of group members in discussion is important in improving idea generation productivity while in synchronous meetings, the process loss of production blocking plays a crucial role.

THE IMPACTS OF DELPHI COMMUNICATION STRUCTURE ON SMALL AND MEDIUM SIZED ASYNCHRONOUS VIRTUAL TEAMS

by
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THE IMPACTS OF DELPHI COMMUNICATION STRUCTURE ON SMALL AND MEDIUM SIZED ASYNCHRONOUS VIRTUAL TEAMS

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TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

LIST OF TABLES

LIST OF TABLES
(Continued)

LIST OF TABLES
(Continued)

LIST OF TABLES
(Continued)

LIST OF TABLES
(Continued)

Table **Page**

LIST OF TABLES
(Continued)

LIST OF TABLES
(Continued)

LIST OF TABLES
(Continued)

LIST OF TABLES
(Continued)

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Groups are the major component in organizations producing the knowledge that influences decision outcomes. Combining diverse backgrounds and knowledge, contributing different insights toward problems and checking and correcting each other's judgments are potential advantages of group decision making. However, groups often fail to utilize their full potential due to process losses and this tendency is stronger when group size increases. Despite of this shortcoming, organizations still rely on group decision making especially in the case when the commitment of decisions is as important as the quality of decision. One of the most important objectives of group research is to improve group meetings. Meeting is defined (Bostram et al., 1993; pp. 148) as "a goal- or outcome-directed interaction between two or more people that can take place in any of four environments –same time / same place, same time / different place, different time / same place, different time / different place." Same time / same place is the typical environment of face-to-face meetings or synchronous decision room Group Support Systems (GSS) meetings. Face-to-face meetings are usually conducted in verbal-mode conversation. Synchronous decision room GSS meetings are usually conducted in the combination of verbal and text-based mode. Same-time / same place is the environment of synchronous computer-based remote meetings wherein members conduct conversation through networked computers at the same time. Different time/ different place represents the typical form of asynchronous computer-supported meetings wherein members log into the Web-based group communication system and contribute at any time and place.

Since meetings are likely to become less efficient by having more people in a group, group size has been important concerns in group research. As group size becomes larger, more process losses are likely to involve in meetings; Members in a large group may compete more for their turns to talk. In large groups, it might be difficult to explore every single member's diverse ideas or judgment. Furthermore minority opinion holders have less chance to speak up their positions. The larger the group, the more efforts of communication and coordination are needed to make the meeting effective. Meeting facilitation has been used to improve the productivity of a meeting through the reduction of possible process losses. In traditional non-computer supported meetings, facilitation is implemented by a human facilitator who provides appropriate procedural structures and emotional supports to the group. The emergence of Group Support Systems (GSS) provides a new source of meeting facilitation by the utilization of hardware and software facilities as well as human facilitation.

The place and the time in which the meeting is held are critical factors in the implementation of meeting facilitation. Traditional meetings usually have been held in face-to-face modes. However the advance of Internet made "virtual" meetings possible with the use of asynchronous group communication technologies such as email or conferencing systems. In those asynchronous group communications, dispersed groups collaborate by making contributions at any time and place. However, this lack of sharing time and place among members may make this mode of communication very confusing and difficult to use, resulting in many problems such as inactive participation, high dropout rates or the "multi-headed animal syndrome." Group interactions and dynamics in asynchronous meetings are very different from synchronous decision room meetings and it has been a general belief that some form of facilitation is necessary to make this distinctive form of meeting work. However, previous empirical studies in asynchronous group communications have been focused on comparing this mode of communication with face-to-face counterparts (Hiltz and Turoff, 1986; Ocker et al., 1995/1996; Ocker and Yaverbaum, 1999; Raquel et al., 2002; Shirani et al, 1999) and the characteristics which make desirable forms of facilitation in asynchronous meetings are not well-known. Enforcing a communication structure with the facilitator supports is the most popular form of facilitation and a few empirical studies investigated the effects of different facilitated structures in structuring asynchronous meetings but did not show significant findings (Hiltz et al., 1996). Since one of the main purposes of facilitation is to reduce process losses possibly introduced by coordinating problems of larger sized group, the effect of group size is also worth investigating. However, previous empirical GSS studies on group size were done in synchronous GSS meeting environments and there was no attempt to study the effect of group size in asynchronous environments.

From the above motivation, this study investigates the effects of facilitated asynchronous meetings on groups of different sizes. Delphi structure is chosen in this study since it is the most popular structure facilitating geographically and temporally dispersed groups.

CHAPTER 2

LITERATURE REVIEW

The purpose of this chapter is to review previous literature to generate the research questions of this study. Section 2.1 examines the concepts of the process gains and losses because it is a key factor to determine the meeting productivity. The issues of the process gains and losses are mainly emerged in the process of accommodating a large sized group. Thus, Section 2.2 discusses the issue of group size and the previous empirical GSS studies on the group size. Asynchronous meetings can accommodate in a group more members especially dispersed in time and place and the characteristics of asynchronous group meetings are discussed in Section 2.3. Process structuring efforts by the use of intervention techniques were examined and especially the Delphi which is used to structure asynchronous meetings was discussed in more detail in Section 2.4. In GSS, process structuring is mainly done in the form of facilitation and the empirical GSS studies on facilitation were reviewed in Section 2.5.

2.1 Meeting Productivity (Process Gains / Losses)

Meeting productivity is determined by the net effect of process gains (factors enhancing the productivity of group meetings) and process losses (factors inhibiting the productivity of group meetings) (Steiner, 1972). Pinsonneault et al. (1999) surveyed the process gains and process losses from the previous literatures (See Table 2.1 for details). Communication structure such as NGT / Delphi or other procedural agenda enforced by facilitators can divide a task into manageable chunks or separate idea generation phase from idea evaluation phase. **Parallelism** can be given when discussion does not require immediate feedback, which is either asynchronous mode of communication or communication structure enforcing nominal contributions.

There are two kind of blocking effects in idea generation: production blocking and cognitive interference. Production blocking occurs when one member's opportunity to express his/her own idea is blocked when groups have constraints to talk only in turn. Being prohibited from contributing their ideas at the time when they occur, group members might forget them or suppress them because they seem less relevant or less original later at time. Individuals sometimes rehearse ideas to avoid forgetting ideas and it might prevent them from generating new ideas (Stroebe and Diehl, 1994). This effect is severe in synchronous meeting environments wherein members share time of speaking. Even though GSS (EBS) which pools and feeds members ideas one at a time may reduce this effect, members still experience this effect since their mode of contributions is synchronous in nature. On the other hand asynchronous meetings do not suffer from production blocking since members make contributions in independent and parallel manners. Cognitive interference refers to the negative effect of other members' contributions on a member's cognition and thinking process, while production blocking refers to simple loss of opportunity of contribution. Cognitive interference is the effect that exposure to the ideas of others is distracting and thus interferes with individuals' own thinking process or creativity. As well as any synchronous-type meeting (such as face-to-face or synchronous GSS meetings), asynchronous meetings may also affected by the process loss of cognitive interference if a member can see the ideas posted by other members before he/she generate their own. Facilitated communication structures (such as NGT or Delphi) may reduce this process loss since this structure can enforce each member fully deliberate on the problem and generate his/her own ideas alone before he/she is given feedback of other members' contributions.

An individual who generate ideas alone without being given information about the ideas generated by others, may not have opportunity to eliminate duplicate ideas and groups have to spend much of their efforts and time to remove those duplications later on. Also, individuals or unstructured groups may experience cognitive inertia which makes them pursue a single train of thoughts for a long period, drifting from the intended goal. Furthermore, interacting groups tend to focus on a few narrow topics and keep generating similar ideas. In this case, a facilitator's intervention with procedural remarks could be helpful.

Paulus and Dzindolet (1993) found that the level of performance in groups was affected by the mere fact that members had information on the performance of others and found a higher correlation between the participants' productivity and their group mean in interacting groups than nominal counterparts. This phenomenon is called production matching and has the effect of equalizing performance between high performers and low performers. This phenomenon has dual effects—promoting motivation of low performers' motivation but at the same time demoting the high performer's efforts. Any communication mode– face-to-face, synchronous GSS or asynchronous GSS– which allows members to check other members' performance while they perform may be affected by production matching. In fact, production matching effect of GSS is consistent with the previous research findings that suggest GSS helps a group perform better than its average member but does not help a group perform better than its best member.

Synergy refers to the effect of "total value of a system is greater than the sum of its parts (Hill, 1982)." Roy and Gauvin (1996) categorized group synergy into social and intellectual. They stated, "Social synergy is activated by presence of other members, whereas intellectual synergy is activated by the ideas of others." Osborn (1957) suggested that brainstorming is effective due to (intellectual) synergy (i.e. piggybacking or cognitive stimulation) effect wherein a member could come up with a new idea through stimulating from ideas of other members. Cognitive stimulation in groups may produce more novel and/or creative ideas by sparking a new idea by having inspiration by others' ideas or by combining different ideas contributed by others. Sosik and Avolio (1998) stated that intellectual synergy would promote creativity by enhancing generative (divergent) thinking and exploratory (convergent) thinking. Divergent thinking relates to questioning assumptions, rethinking ideas and looking at problems from different perspectives. Convergent thinking relates to clarifying and elaborating ideas. Even though group communication can produce some level of synergy, adding a structure in discussion such as providing a feedback of voting result may help a group to reach a higher level of intellectual synergy.

Members working in a group can learn and imitate best performers (Hill, 1982). Members can share diverse knowledge and information through group communication that facilitates information exchange among group members. Therefore, by communicating in a group, members could earn more factual information on a particular subject area. Collaborative learning refers to the mode of learning that involves social processes and small group communication and has been shown an effective learning mode (Hiltz, 1995). Proponents of collaborative learning suggest that learning is not mere acquiring of factual information, but rather building emergent body of knowledge through group discussion and this can be one of the important objectives of having meetings in an organization.

Free-riding refers to the phenomenon that members working in a group might limit their efforts and contributions by relying on others to accomplish the task and this effect is due to: (1) perceived dispensability of one's effort, (2) diffused responsibility, or (3) social loafing (Pinsonneault et al., 1999). In order to reduce an individual's propensity to loaf; (1) individuals should perceive their contributions to be unique, (2) they should work in small groups, (3) they should receive some feedback so that they could compare their own performance with that of other members, such as the public display of ideas in EBS, (4) they should be provided some output measure (e.g., how many ideas a person generates) and some standard against which this output can be compared (e.g., the number of ideas generated by others in the group) (Roy and Gauvin, 1996).

In an unstructured group communication mode, a few members may dominate discussion or exercise undue influence. This may cause other members to feel pressure to remain within group or social norms rather than expressing their own opinions. (Janis, 1972; McGrath, 1984) Incomplete survey of alternatives, poor information search, failure to examine risks of the preferred choice and to reappraise initially rejected alternatives could lead groups to groupthink (Janis, 1972), resulting in a sub-optimal decision.

People tend to withhold ideas because they fear a negative evaluation of their ideas (Stroebe and Diehl, 1994). The previous studies on the effect of GSS have shown that face-to-face groups generally have higher evaluation apprehension than their electronic counterparts (Aiken et al., 1994; Dennis and Valacich, 1993; Gallupe et al, 1992). However, most of those studies confounded the effect of technology and communication structure (nominal vs. interacting). With respect to the communication structure, previous studies showed the general tendency of the superiority of interacting groups to nominal counterparts. Gallupe et al. (1991) found that there was no difference in the level of evaluation apprehension between electronic and face-to-face groups, but nominal groups have higher level of evaluation apprehension than interacting groups. Cooper et al. (1998) found anonymous EBS groups had significantly lower evaluation apprehension than identified EBS groups and nominal groups had higher evaluation apprehension than interacting groups. In general, large groups are expected to have lower evaluation apprehension than small groups because of low identifiability. However, the findings of the previous studies were mixed. Aiken et al. (1994) found large groups had higher evaluation apprehension than small groups. On the other hand, Gallupe et al. (1992) and Dennis and Valacich (1993) did not find significant effect between small and large groups.

Table 2.1 Process Gains / Losses in Different Communication Modes

Process Gains / Process Losses	Description	Indiv.	F-to-F	Synch. GSS	Asynch. GSS	NGT / Delphi	Anonymity
Coordination-related Process Gains	**Effective coordination in performing the task will improve the group productivity**						
Separation of idea generation and evaluation	Separation of idea generation and idea evaluation					++	
Task decomposition	A task is decomposed into several sub-tasks or procedural agenda					++	
Parallelism	Member simultaneously contribute ideas or involve in any part of the problem regardless of what other members are focusing on at the point	++			++		
Social Psychology-related Process Gains	**The positive social and psychological effects associated with the presence of other people and by individual membership in a group**						
Positive production matching	The information on other members' performance promotes the low performers in the group, resulting adjustment individual productivity to the average.		++	+	+		
Cognitive stimulation/ Intellectual synergy	Utterance of members may contain task related stimuli that elicit new ideas from other members		+	+	+	++	
Observational learning	Members can learn from and imitate best members, hence increase group productivity		++	++	++		
Social recognition	Individuals want their contributions to be recognized by others		++	++	+		
Task orientation	Productivity is improved when discussions are task-oriented rather than socializing	+			+		+

Table 2.1 Process Gains / Losses in Different Communication Modes (Continued)

Process Gains / Process Losses	Description	Indiv.	F-to-F	Synch. GSS	Asynch. GSS	NGT / Delphi	Anonymity
Motivation-related Process Gains	**The factors that positively affect the motivation of individuals and their desire to contribute to group outcomes**						
Motivational/arousal	Working in groups stimulates individuals to perform better		+	+	+	+	
Coordination-related Process Process Losses	**Ineffective coordination in performing the task will improve the group productivity**						
Production blocking	An individual's opportunity to express his/her own idea is blocked when groups have constraints to talk only in turn.		--	-			
Effort redundancy	Generating duplicate ideas	-				-	
Cognitive interference	Exposure to the ideas of others is distracting and interferes with individuals' own thinking		--	-	-		
Cognitive inertia	Instead of searching a diverse set of ideas, groups or individuals pursue a single train of thought for long periods, drifting from the intended goal (Voelker, 1976). Therefore, they focus on a few narrow topics so that later contributions tend to more closely resemble earlier ones (Dennis et al., 1997).	--	--	-	-		
Social Psychology-related Process Losses	**The negative social and psychological effects associated with the presence of other people and by individual membership in a group**						
Evaluation apprehension	Members withhold ideas because they fear a negative evaluation of their ideas (Dennis, 1993).		-	-	-		

Table 2.1 Process Gains / Losses in Different Communication Modes (Continued)

Process Gains / Process Losses	**Description**	**Indiv.**	**F-to-F**	**Synch. GSS**	**Asynch. GSS**	**NGT / Delphi**	**Anonymity**
Negative production matching	The information on other members' performance demotes the high performers in the group, resulting adjustment individual productivity to the average.		--	-	-		
Pressure to conformity	Members may feel pressure to remain within group or social norm		--	-	-		
Motivation-related Process Gains	**The factors that positively affect the motivation of individuals and their desire to contribute to group outcomes**						
Motivational/arousal	Working in groups stimulates individuals to perform better		+	+	+	+	
Coordination-related Process Process Losses	**Ineffective coordination in performing the task will improve the group productivity**						
Production blocking	An individual's opportunity to express his/her own idea is blocked when groups have constraints to talk only in turn.		--	-			
Effort redundancy	Generating duplicate ideas	-				-	
Cognitive interference	Exposure to the ideas of others is distracting and interferes with individuals' own thinking		--	-	-		
Cognitive inertia	Instead of searching a diverse set of ideas, groups or individuals pursue a single train of thought for long periods, drifting from the intended goal (Voelker, 1976). Therefore, they focus on a few narrow topics so that later contributions tend to more closely resemble earlier ones (Dennis et al., 1997).	--	--	-	-		

Table 2.1 Process Gains / Losses in Different Communication Modes (Continued)

Process Gains / Process Losses	Description	Indiv.	F-to-F	Synch. GSS	Asynch. GSS	NGT / Delphi	Anonymity
Social Psychology-related Process Losses	**The negative social and psychological effects associated with the presence of other people and by individual membership in a group**						
Evaluation apprehension	Members withhold ideas because they fear a negative evaluation of their ideas (Dennis, 1993).		-	-	-		
Negative production matching	The information on other members' performance demotes the high performers in the group, resulting adjustment individual productivity to the average.		--	-	-		
Pressure to conformity	Members may feel pressure to remain within group or social norm		--	-	-		
Personalization of issues	Members associate the discussion of issues to personal matters		--	-	-		
Social influence	Domination by a few members exercising undue influence		--	--	-		
Premature closure	The goal of achieving the best possible judgment is often supplanted by the goal of simply reaching agreement. Hence, the premature closure and satisficing may dominating optimizing, with consensus accepting the first solution that greatly offends no one, even though no one agree with that solution wholeheartedly. (Rowe et al., 1991)	-	--	-			
Motivation-related Process Losses	**The factors that positively affect the motivation of individuals and their desire to contribute to group outcomes**						
Free-riding / Social loafing	Members working in a group might limit their efforts and contributions by relying on others to accomplish the task		-	-	-		-

2.2 Group Size

The process gains / losses are affected by the group size in a great extent and the research to investigate the natures of group decision making started from the basic belief of "N+1 heads are better than one" principle. One line of this research is comparing individual and group performances. Hill (1982) reviewed the previous research in terms of three measures used to compare the group output to (a) average individual performance, (b) the most competent member of a statistical aggregate, and/or (c) a statistically pooled response. He concluded that group performance was generally superior to the performance of the average individual but groups often fail to incorporate the best ideas of their members. The study of Miner, Jr. (1984) also confirmed this belief. There are many studies showing that pooling of individual responses frequently produced a greater number of unique ideas than did group interaction in brainstorming because of the ability of individuals to produce a greater number of ideas when working separately (Bouchard, Jr. and Hare, 1970; Bouchard, Jr. et al., 1974; Hill, 1982).

The other line of research is investigating the optimal group size. In their review, Hackman and Vidmar (1970) stated that previous results regarding the effect of group size on group performance have not been consistent. A study by Hackman and Vidmar (1970) showed that optimal satisfaction with group size is between four and five members.

Most of the research on the effect of different group sizes in Group Support Systems (GSS) involved in computer brainstorms using idea generation tasks. Table 2.2 summarizes the previous GSS research on group size. Most of the research used group size and technology (electronic brainstorming vs. verbal brainstorming) as independent variables and the effectiveness (i.e., the number of unique ideas, the quality of ideas) and the perceived effectiveness (satisfaction, perceived process gains / losses) as their main dependent variables. In general, large groups were found to be more effective in terms of the number of unique ideas and quality of ideas. Interaction effects were found between group size and technology in a sense that large groups benefit more from computer technology than small groups. Valacich et al. (1992) investigated the effects of group size and anonymity. They found that small groups are more effective and satisfied in identified conditions while large groups are more effective and satisfied in anonymous conditions. One of the most plausible explanations of the superiority of large groups is that large groups have a higher possibility to include members with diverse knowledge. Valacich et al. (1995) investigated the effects of group heterogeniety in regard to task-related knowledge. They found that large groups outperformed small groups and heterogeneous groups had greater performance gains than homogeneous groups did when adding additional members.

There is no empirical GSS study providing conclusive evidence of the superiority of large groups in terms of per person performance. However, Dennis and Valacich (1993) reported an interaction effect between the effect of group size and technology: Large (12 members) groups had more benefits of computer support than small (6 members) groups, in terms of per person ideas. Based on Pinsonneault et al.'s review (1999) which reviewed five studies which compares electronic brainstorming groups to nominal (or pooled) groups, electronic brainstorming was found to be superior only to nominal idea generation for large (larger than nine) pooled nominal groups only.

In Delphi research, the impact of the group size has been considered by Brockhoff (in Lintone and Turoff, 1975) (size; 5, 7, 9, and 11) and Boje and Murnighan (1982) (size; 3, 7, and 11). Neither of these studies found a consistent relationship between panel size and effectiveness criteria.

Table 2.2 Previous GSS studies on Group Size Effect

Study	Subjects	Task	Indep. Var.	Dep. Var.	Results
Dennis et al. (1990)		Identifying stakeholders affected by a proposal requiring all business students to have individual access to a personal computer	Group size (3 X 9 X 18)	Effectiveness (Number of unique ideas, Quality of ideas), Perceived effectiveness, Average per-person participation, Perceived participation, satisfaction	Effectiveness : large > small Perceived effectiveness: large > small Perceived participation per person: large = small Satisfaction: large > small
Dennis et al., 1991 (Study 1)	259 Business students	Identifying stakeholders affected by a proposal requiring all business students to have individual access to a personal computer	Group size (3 X 9 X 18 member-group)	Number of unique ideas, Quality of ideas	Single 18-member group > two 9-member group > 18 pooled > six 3-member group
Dennis et al., 1991 (Study 2)	164 subjects		Group size (4 X 12 member-group)	Number of unique ideas, Quality of ideas	12-member group > 12 pooled > three 4-member group
Gallupe et al. (Study 1) (1992)	120 under grad.	Tourism and security	Technique (electronic X non-electronic brainstorming) Group Size (2 X 4 X 6)	Number of unique ideas	Main effect for both dimensions: electronic > non-electronic Large (4, 6) > Small (2) Interaction effect: 4, 6 electronic > 2 electronic 4, 6 non-electronic = 2 non-electronic

Table 2.2 Previous GSS studies on Group Size Effect (Continued)

Study	Subjects	Task	Indep. Var.	Dep. Var.	Results
				Quality of Ideas	Same as the above
				Perceived Process Gain / Loss (production blocking, evaluation apprehension, satisfaction)	Large groups have more production blocking than small groups. Interaction effects found
Gallupe et al. (Study 2) (1992)	144 under grad.	Tourism and security	Technique (electronic X non-electronic brainstorming) Group Size (6 X 12)		
Valacich et al., 1992	126 under grad.	Identifying stakeholders affected by a proposal requiring all business students to have individual access to a personal computer	Anonymity (anonymous X identified) Group Size (3 X 9)	Number of unique ideas	Main effect for group size (large > small)
				Quality of Ideas	Main effect for group size (large > small)
				Perception (satisfaction, effectiveness)	Interaction Effect (small-identified > large-anonymous)

Table 2.2 Previous GSS studies on Group Size Effect (Continued)

Study	Subjects	Task	Indep. Var.	Dep. Var.	Results
Dennis and Valacich, 1993	276 under grad.	Generate ideas for encouraging tourists and improve security on campus	Technique (electronic X nominal brainstorming) Group Size (6 members X 12 members)	Number of unique ideas)	Main effect for group size: (12 members > 6 members) Interaction effect: 12 electronic > 12 nominal 6 electronic = 6 nominal
				Number of unique ideas per person	Interaction effect: 12 electronic > 6 electronic 12 nominal < 6 nominal
				Perceived Process Gain / Loss (production blocking, evaluation apprehension, synergy and stimulation, satisfaction, sufficient time, free riding)	No effect found for group size
Aiken et al., 1994	242 under grad.	Tourism and campus parking problem	Technology (electronic X verbal) Group Size (small: 8 X large: 48)	Production blocking	Main effect for technology: (verbal > electronic) Main effect for group size: (large > small) Interaction effect: large electronic = small electronic large verbal > small verbal
				Evaluation apprehension	Same
				Satisfaction	Same

Table 2.2 Previous GSS studies on Group Size Effect (Continued)

Study	Subjects	Task	Indep. Var.	Dep. Var.	Results
Valacich et al. (1995)	360 undergraduates	SOB Policy Task (hidden-profile)	Group size (5–10) X Logical group size (Homogenous X Heterogeneous)	Total number of solutions, Number of unique solutions, Number of high quality solutions, Individual member contribution	1.The performance of heterogeneous groups improved at a higher rate for increased group size than the performance of homogeneous groups. 2. The average member contribution in homogeneous groups diminished with increased group size at a higher rate than average member contribution in homogeneous groups.

2.3 Asynchronous Group Meetings

Face-to-face meetings become ineffective when they are too crowded. Synchronous GSS meeting is a form of meeting using computers to increase the productivity. The asynchronous meeting is a unique form of group meeting, distinguished not only from the face-to-face meeting, but also from the synchronous GSS meeting (Benbunan-Fich et al., 2002). In asynchronous meetings, groups conduct text-based discussions through the use of computer conferencing systems wherein geographically and temporally dispersed members can contribute at any time and place. This unique form of group communication is called asynchronous group communication system. The asynchronous group communication system provides a shared group memory wherein all the comments of group members could be organized, saved in computer storage and retrieved by other members later in time.

In terms of media characteristics, asynchronous group communication can be compared with its synchronous counterpart by Media Synchronicity Theory (Dennis and Valacich, 1999). This theory suggests that the choice of communication medium should be determined by the characteristics of the message a sender wants to deliver and the task a group is dealing with. Based on this theory, communication media is characterized by five dimensions; immediacy of feedback, symbol variety, parallelism, rehearsability, and reprocessability. Among those five dimensions, asynchronous and synchronous communications are different in the four dimensions– immediacy of feedback, parallelism, rehearsability, and reprocessability.

Immediate feedback can improve the efficiency of communication and gives discussion sequential linearity. This sequential linearity provides understandable context or history of discussion so that members can easily follow the discussion. Immediate feedback is also important for converging members' diverse opinions or building shared understanding of the issues by clarifying the meaning, context, and intentions of messages. On the other hand, by providing immediate feedback, members are given higher cognitive burden in interpreting a vast amount of information and responding to it at the same time. One of the most distinctive attributes of asynchronous meetings distinguished from synchronous meetings (face-to-face or decision room GSS) is that a member can contribute whenever he/she has useful inputs and feel comfortable to make such contributions. In a synchronous meeting, a member's contributions are constrained by the time limit and the pace of the group process; members have multiple cognitive burdens of contributing their own ideas, responding to other members' ideas and following the pace of group discussion at the same time. Usually a group discussion consists of several different phases which deal with different aspects of the problem. Being prohibited from contributing their ideas at the time when they occur, group members might suppress them because they seem less relevant or less original when the group discussion turn into a new phase (Stroebe and Diehl, 1994). On the other hand, in an asynchronous group meeting, each individual can have time to consider what other members have said, have more reflections on the problem, and contribute their own thoughts without being interfered by others' contributions. Therefore, an individual can adjust his/her own pace in the problem solving process to accommodate his/her own personal situations, encouraging him/her deeper reflection in his/her information processing. This more complete deliberation on the problem may result in more creative solutions (comparing to face-to-face meetings) (Ocker et al., 1998/1999) or generating inferential ideas using reasoning and implication (Shirani et al., 1999), comparing to face-to-face or synchronous GSS meetings.

Parallelism refers to the capability of communication medium which allows multiple simultaneous conversations or information processing at the same time. Parallelism enables members to exchange information simultaneously without waiting for his or her turn to contribute and thus reduces production blocking. In an asynchronous group meeting, a group can deal with multiple aspects of the problem at the same time by giving a set of different conferences (a working space to meet a specific objective) and each individual can focus his/her efforts on any part of the problem and contribute to the part he/she feels the most comfortable with, regardless of where the other members are in the process (Turoff et al., 1993). This parallel information process is difficult in a synchronous meeting due to the limitation of cognitive capability of an individual. Parallelism of asynchronous communication may lead more equal participation in discussion (Dubrovsky et al., 1991; Siegal et al., 1986), resulting in broader issues to be covered in discussions (Benbunan-Fich, 2002).

Temporal illinearity and parallelism of asynchronous meetings could also be a challenge, despite of its flexibility. In synchronous meetings, a message can be easily comprehended by the context of temporally linear discussion. However, due to the asynchronous and parallel contributions, the context of a message contributed in an asynchronous meeting is not as clear as in a synchronous meeting. This lack of temporal linearity in asynchronous communication cause conversations fragmented so that it is hard for members to follow the discussion (Dowling and Louis, 2000). Threaded discussions in a conferencing system were designed to build a context of discussion by filling the temporal gaps between a message and a feedback with a visual structure (such as a tree structure). However due to a long time lag between a message and a response, members may still have difficulty in converging divergent opinions. Therefore, members in asynchronous groups may have difficulty in reaching a consensus and take a longer time to reach a decision (Hollingshead et al., 1993). Overcoming this coordination problem would be one of the most important issues in asynchronous group communication research.

Rehearsability is the capability of communication medium that a sender can fine-tune or edit his/her message before sending (Schmidt et al., 2001). By fine-tuning or editing his/her message, a sender can make sure that the message really expressed what he/she originally meant. By doing so, rehearsability can reduce the possibility of misunderstanding but tends to increase time lag between a message and a feedback. Asynchronous group communication systems provide high rehearsability since a member edits a message in a client computer and uploads it to a server.

Reprocessability is the extent to which a message can be re-examined or processed again (Dennis and Valacich, 1999). It enables groups to store a message once produced in a shared group memory so that individuals reexamine it or reprocess it into a useful form (such as quoting or forwarding) later in time. Reprocessability becomes more important when the volume and complexity the message increase and there is a need for sharing information in a large sized group. Asynchronous group communication systems provide a shared group memory where messages are stored in a meaningful manner (e.g. in a hierarchical discussion threads or through a search function), so that a member can search and use a specific message when necessary. Parallelism, rehearsability, and reprocessability of asynchronous communication medium, make virtual teams made more effective decisions than face-to-face groups in the context of New Product Development decision making (Schmidt et al., 2001).

Text-based communication without direct interactions between group members tends to be more task-oriented and less social-emotional oriented (Hiltz et al., 1982; Gallupe and McKeen, 1990). Low social presence in text-based communication medium encourages members to exchange more task-oriented information and less social-emotional contents, increasing the potential of achieving better quality decisions (Hiltz et al., 1982; Schmidt et al., 2001).

2.4 Process Structuring

2.4.1 Process Intervention Techniques

A variety of group process intervention techniques were developed to improve coordination problems in group meetings. Process intervention techniques are techniques that structure a meeting by providing a prescribed set of rules and/or formal structures (such as procedures or meeting agenda) in group communications (Sniezek, 1989; Voelker, 1976). Different group techniques enforce different rules and/or structures. Brainstorming (Osborn, 1957), Constructive Consensus (Fjermestad et al., 1995; Sniezek, 1989), Dialectic Inquiry (Fjermestad et al., 1995; Sniezek, 1989), Dictator (Miner, 1984; Sniezek, 1989), Nominal Group Technique (NGT) (Van de Ven and Delbecq, 1974; Voelker, 1976) and Delphi (Dalkey and Helmer, 1963) are examples of process intervention techniques.

For example, Brainstorming (Osborn, 1957) is a popular idea generation technique developed under by Osborn (1957) based on two principles of "determent of judgment" and "quantity breeds quality". The principle of determent of judgment implies the separation of idea generation and idea evaluation and the application of this principle should enhance the quantity of ideas generated, and thus according to the "quantity breeds quality" principle, also the quality of ideas will be guaranteed (Stroebe and Diehl, 1994).

In Electronic Brainstorming Systems (EBS), a computer pools ideas contributed by members, then from this central pool randomly pick an idea and send to members who in turn can use this as a seed for generating another idea. EBS is expected to outperform not only face-to-face idea generation because of the computer features supporting anonymity and reducing production blocking. EBS groups are also expected to outperform nominal groups in which participants generate ideas alone without seeing the ideas produced by other group members, mainly because of their relative efficiency in avoiding redundant ideas and synergy effects. However, the superiority of EBS over other idea generation process (especially nominal idea generation) is not conclusive. Pinsonneault et al. (1999) reviewed five studies that compared EBS to other forms of idea generation– *nominal* groups in which members generate ideas without seeing the ideas produced by other members and *pooled nominal* groups which were artificially formed after the experiment by randomly pooled together the ideas generated by individuals working independently and asynchronously. Their analysis suggests the following; (1) Nominal groups are as effective as EBS in terms of generating unique ideas, (2) For groups consisting of less than nine members, EBS groups were never found to generate more unique ideas than nominal groups, (3) Even for larger groups, EBS was found to be superior only to *pooled nominal* groups which were artificially formed groups after the experiment, (4) EBS groups were more satisfied with their ideas generation process than nominal or pooled nominal groups. Furthermore, most of EBS studies compared computer-supported (electronic) process (brainstorming) with manual process (nominal idea generation), resulting in the confounding effects between technology and process. Hymes and Olson (1992) investigated this confounding effect of technology and process and they found that the use of a simple technology (editor allowing parallel inputs) increased the performance of unstructured face-to-face groups in idea generation. However, the use of the simple editor did not improve the face-to-face groups' performance to an extent that they could outperform nominal groups. Their results suggest that the use of simple technology can improve the effectiveness of face-to-face groups in idea generation, even without enforcing any formal structure in the idea generation process.

Nominal Group Technique (NGT) (Van de Ven & Delbecq, 1974) is a process intervention technique for structuring face-to-face meetings. In NGT, members individually generate their own ideas and each of them is asked to nominate one of his/her ideas at a time in a round robin fashion. Then they have an opportunity to clarify the definitions and significances of the ideas they generated in the previous session. They are also asked to refine the list of ideas by removing duplicate or irrelevant ideas and combining or disaggregating ideas. Then, the group evaluate the ideas they generated by rating or ranking them by an appropriate criteria. These steps are iterated until there is a reasonable amount of agreements among group members on the issues.

The common philosophy of NGT and Delphi is an attempt to combine the best features of individual and group decision making strategies, specifically as an attempt to combine pooling of individual ideas and written feedback of group (Hill, 1982). Among the above group communication structures, Delphi is the only process intervention technique that does not allow group members to meet face-to-face. Since the focus of this study is structuring discussions in asynchronous environments, Delphi structure will be discussed in more detail in the next sub-section.

2.4.2 Delphi Technique

The Delphi technique was developed by Norman Dalkey and his associates at the RAND Corporation. (Dalkey and Helmer, 1963) Delphi technique has been utilized as a method to obtain judgments or opinions on a particular topic from physically dispersed groups of experts through a set of carefully designed sequential questionnaires combined with summarized information and feedback of opinions derived from earlier responses (Turoff, 1970). The advantages of Delphi can be illustrated by the following situations.

- The problem is so ill-defined that it cannot benefit from precise analytical technique, but can benefit from subjective judgment on a collective basis. (Linstone and Turoff, 1975)
- The problem is so complex that it has no proven single method or data to solve this problem.
- The problem is so broad that no single individual perfectly understands the full scope of the problem.
- There is a need to obtain views and judgments from participants, who constitute a large group, who have diverse backgrounds, who have strong disagreements, who are geographically dispersed, or who have severe time limitations in participating.

The traditional Delphi (i.e. paper and pencil Delphi) technique used survey questionnaires to obtain opinions from experts who were possibly geographically-dispersed. Delphi uses feedback and iteration in order to achieve consistency by reducing biases of individual and group intuitions. Usually Delphi undergoes four distinct phases: *Exploration* of the subject under discussion; *Mutual understanding* of group members' viewpoints; *Reasoning* of disagreement in the group; and *Analysis and Feedback* of contributions and group judgments (Linstone and Turoff, 1975).

Different Delphi implementations used different procedures and there is no standard procedure of Delphi. But there are seven main characteristics used in most of all Delphi implementations.

(1) *Anonymity*: Group members' contributions are conducted anonymously in order to prohibit undesirable social pressures.

(2) *Facilitation*: There is a facilitator who plans the Delphi procedure, designs and makes survey questionnaires, organizes the list of items contributed by the participants, analyzes the responses, makes and distributes the report, and facilitates the participants.

(3) *Delivery* (Asynchronous Communication Medium): In order to gather ideas or opinions from participants who are geographically dispersed and also have time limitation to participate in a synchronous discussion, an asynchronous communication medium to deliver the participants' contributions and to distribute the report. Mailed questionnaire and report are used in the paper and pencil based Delphi. The facilitator mailed a survey questionnaire to the participants to collect their ideas or opinions and the participants are asked to mail back their responses to the facilitator. Then the facilitator a report from the summarized responses and mail this report to the participant. In this way contributions of the members are done in asynchronous manners.

(4) *Nominal Idea Generation*: This phase corresponds to the 1st round of the paper and pencil Delphi and participants are asked to list their initial ideas in a questionnaire form. In this way, group members contribute their opinions or ideas alone.

(5) *Group Feedback*: In the paper and pencil Delphi, after collecting participants' responses, the facilitator analyzes those responses and makes a summarized report. Then this report is mailed to the participants along with the subsequent questionnaire.

(6) *Controlled Discussion*: In Delphi, direct discussions among the participants are prohibited to reduce the potential process losses. Instead of having direct discussions, a participant indirectly interacts with other participants through a series of questionnaire, through the activities of adding additional ideas, responding to other participants' ideas or opinions, or updating their original judgments based on what the group views the problem. In this way, participants conduct controlled discussion through "response-feedback-change." In most cases, voting is used to give each participant an opportunity to compare his/her own view with the viewpoint of the group.

(7) *Iteration*: The process of response-feedback-change is iterated until a certain level of consensus reached or the changes in an individual's response has been stabilized to a certain level.

There are two lines of research in Delphi: evaluative studies and field studies. The controlled experiments using Delphi involve evaluation of the Delphi technique as a decision-making tool. The field studies using Delphi involve studies of applications in various subject areas such as policy evaluation, medical, education, management, etc, by gathering expert opinions. Rowe and Wright (1999) categorized evaluative studies of Delphi into two categories: technique comparison studies, which compared the effectiveness of The Delphi groups with groups using no communication structure or other group techniques such as NGT, and process studies, which investigated "which factors of Delphi would make it work?" They reviewed 27 published studies involving evaluation of the Delphi technique. They reported Delphi has relative advantage over interacting (i.e., unstructured) face-to-face groups by a score of five studies to two with two ties, and with one study showing task-specific support for both techniques. Process studies investigated the roles of various factors of Delphi, such as feedback or the nature of panelists.

Delphi technique has been criticized (Sackman, 1975) for lack of demonstration of its validity and reliability since there is no standardized Delphi structure. Previous Delphi research mainly focused on the question of "Does Delphi work?" by comparing the Delphi technique to other group techniques or unstructured face-to-face meetings. The results of technique comparison studies are mixed—some of the study showed relative superiority of Delphi over other group techniques, but the others showed the opposite direction (Rowe and Wright, 1999). Considering the Delphi consists of many different implementation options, such as different types of feedback (i.e., single number estimates, statistical distribution, ranks, weights, reasons or comments), different number of rounds, and different types of task (i.e., hypothetical events, almanac questions, subjective likelihood, forecasting, idea generation, problem-solving, policy). Lack of standard procedure might make the two different Delphi experiments incomparable. Furthermore, most of the paper-and-pencil Delphi structure was compared with a form of face-to-face structure—such as NGT or unstructured face-to-face groups. However, in these studies Delphi structure is implemented through mailed questionnaires, which is totally different medium from the compared face-to-face meetings. Therefore, comparing Delphi groups to face-to-face groups is misleading as it is not possible to pin point the effects of Delphi as a communication structure through elimination of the confounding effects of communication medium.

The more compelling issue on the Delphi empirical studies is "Why or How does Delphi work?" and the focus of the future Delphi empirical studies should be on the discovery of the effective Delphi implementation on different applications, not on the simple question of "Does Delphi work?" One of the possible reasons for the lack of good process studies investigating the effectiveness of different paper and pencil Delphi implementations might be due to the high operation cost and high dropout rates of the Delphi. However, practitioners of the Delphi view it as a process with specific properties that involves the tailoring of the specifics of the structure to the nature of the application, the group, and the objective (Linstone and Turoff, 1975). With the ability to implement the Delphi on the computer a continuous asynchronous process, there are more opportunities for implementing and testing varied structures of Delphi (Turoff and Hiltz, 1995).

Group feedback is the mechanism of Delphi with which participants conduct controlled discussions. Previous literatures introduced two kinds of feedbacks: outcome feedback providing the result of group decision making process and cognitive feedback clarifying the decision-maker's intentions. In general, previous research showed that outcome feedback did not help GSS groups achieve better outcomes, as opposed to cognitive feedback which did (Bose and Paradice, 1999; Hiltz et al., 1991; Harmon and Rohrbaugh, 1990; Sengupta and Te'eni, 1993). From these results, we can infer that a type of feedback which clarifies group members' thoughts and insights on the problem would be more effective, rather than simple form of feedback showing the results of group decision making. The above findings are consistent with the Delphi research which prove qualitative comments and reasons of their judgments are more effective form of feedback in Delphi than quantitative (e.g., statistical) feedback alone (Best, 1974; Gowan and McNicholas, 1993; Rowe and Wright, 1999). This suggests that the true benefit of Delphi technique may come from qualitative comments reflecting insights of group members, combined with quantitative judgments and here is a big potential of using asynchronous group communication systems for computer-based implementation of Delphi to improve the current practices. An asynchronous group communication system replaces mailed questionnaire providing a virtual place wherein participants discuss the issue without experiencing potential process losses. However in order to enforce nominal contribution and controlled feedback, special features such as facilitation (or moderation) become necessary and the option of automated facilitation can be used as well as human facilitator.

2.5 Meeting Facilitation

2.5.1 Theoretical Backgrounds of Meeting Facilitation

Facilitation is defined (Bostrom et al., pp. 147) as "a set of functions or activities carried out before, during and after a meeting to help the group achieve its own outcomes. The essential characteristic of facilitation is to help make an outcome easier to achieve." Bostrom et al. (?) defined three dimensions of facilitation as; (1) Sources are the initiators of facilitative acts, including people (**human facilitation**; an external facilitator, a leader, group members) or technology (**automated facilitation**; software features in GSS), (2) Targets are what the facilitative acts are trying to influence, including how the group does its work (**process facilitation**), what the group is to achieve (**content facilitation**), and how the group is to use the technology (e.g., GSS) (**technical assistance),** (3) Functions are categorization of facilitative acts or behaviors, including **structure** and **support**.

There are two categories in facilitation sources; human facilitation and automated facilitation (Limayem, 1993; Wong, 2003). Human facilitator could be an *external facilitator* who received professional trainings for facilitation roles or a *group leader* who was selected among group members. Automated facilitation is a facilitation mode in which some facilitation features are built in the software module of GSS; for example, summarizing the previous steps, displaying the current steps and the next steps to be performed, providing explanations of the option chosen, and detecting inconsistencies in group decisions and providing the group a warning.

For content facilitation, the facilitator directly involves in task performance by providing insight, opinion or interpretation of task-related facts (Miranda and Bostrom, 1999). With process facilitation, the facilitator only indirectly influences the task performance of the group by intervening the procedures or relational context of the interactions (Bostrom et al., 1993). Dickson et al. (1993) identified two levels of process facilitation– *task process* which directly involves task-performing processes as well as assistances in technology use and *technology process* which only includes assistances in technology use without direct involvement in task performance. One way of process facilitation to a group is to give a predefined agenda which decompose the task into several sub-tasks. Another way of process facilitation is to enforce pre-defined rules of communications with the use of process interventions discussed in the previous section.

Clawson et al. (1993) surveyed facilitators and developed a topology of 16 facilitator functions including 13 common functions to both GSS and Non-GSS meetings and 3 functions specific to technology-assisted (GSS) meetings (See Table 2.3 for details). These functions are grouped into two categories, structure and support. *Structure* includes (1)meeting outcomes, (2) role specialization, (3) rules to follow during an activity, phase, or entire meeting, (4) Procedures to accomplish an entire meeting, a specific meeting phase, or a specific activity, (5) Techniques/technology to carry out procedures (Bostrom, et al, 1993). *Support* represents a facilitator's communication activities through verbal, nonverbal, and GSS channel, for encouraging effective behavior and minimizing disruptive influences (Bostrom, et al, 1993).

Adaptive Structuration Theory (AST) (DeSanctis et al., 1993) emphasizes the role of group interaction which appropriate ***structures*** which is defined as "formal and informal procedures, techniques, skills, and technologies that organize and direct group behavior processes" (Anson et al., 1995, pp. 192) to guide further group interaction. The AST suggests that meeting outcomes are not a direct result of structures introduced by facilitation or GSS, rather a result of an ongoing process in which groups appropriate structures such as facilitation or GSS over time and invent new social structures which will alter the original facilitation or GSS structure. This theory emphasizes that facilitation is a mediating factors that lead to changes in group interaction, which ultimately change the facilitative structure itself.

Table 2.3 Facilitator Functions by Clawson et al. (1993)

Facilitator Functions Common to GSS and Non-GSS Meetings	Promoting ownership and encouraging group responsibility
	Demonstrating self-awareness and self expression
	Listening to, clarifying, and integrating information
	Developing and asking the right questions
	Keeping the group focused on outcomes
	Creating and reinforcing an open , positive, and participative environment
	Actively building rapport and relationships
	Presenting information to the group; demonstrating flexibility
	Planning and designing the meeting process
	Managing conflict and negative emotions constructively
	Encouraging and supporting multiple perspectives
	Directing and managing the meeting
Facilitator Functions specific to GSS meetings	Appropriately selecting and preparing technology
	Creating comfort with and promoting understanding of technology and technology outputs
	Understanding the technology and its capabilities

Silver (1990) defined "Restrictiveness" as "the degree to which and the manner in which a Decision Supported System (DSS) limits its users' decision-making processes to a subset of all possible processes" (1990, p.53). He argued a system is *highly restrictive* if the number of system-supported processes is small comparing to the number of all possible processes. He also defined "Decision Guidance" as "the degree to which and the manner in which a Decision Support System (DSS) guides users in constructing and executing decision-making processes, by assisting them in choosing and using its operators"(1990, p. 57). He distinguished *decision guidance* which helps users with their interactions with a system's information-processing capability, from *mechanical guidance* which helps users with their interactions with mechanics of operating a system's features. Extending these two attributes of DSS to the context of GSS in the context of AST, Wheeler and Valacich (1996) viewed restrictiveness and guidance as facilitation-related appropriation mediators. They argued that restrictiveness is for preventing unfaithful uses of the pre-defined decision rules or structures, while guidance is for leading groups faithfully to use such rules or structures. In this view, restrictiveness can be defined as "the degree to which GSS limits its users' decision-making process to a particular sequence of operations or pre-described decision path." Groups either adhere to the predefined activities, sequences, or rules of communication (*high restrictiveness*) or choose any option of activities or sequences, without any rule of communication enforced (*low restrictiveness*) (Wheeler and Valacich, 1996). Similarly, guidance can be also defined as "the degree to which GSS guides its users in executing decision-making processes, by assisting them in choosing the system options." Wheeler and Valacich (1996) suggested the three forms of guidance; *forward guidance*, which is to provide the group instructions of what to do next, *backward guidance*, which is to help the group go back and resolve unfinished business from a prior activity, or *preventive guidance*, which is to preventive disruption breakpoints that impede a group's decision progress.

2.5.2 Empirical GSS Studies on Facilitation

There were some GSS empirical studies investigating the effects of facilitation. George et al. (1992) compared facilitated groups who followed a structured process under the guidance of a facilitator who enforced the group to follow the agenda and activated the GSS functions, with user-driven groups who were allowed to devise their own processes and activate the GSS functions whenever desired. They found that facilitated groups were less likely to reach consensus than user-driven groups because the structured process with slower feedback conveys a lower level of information richness. However this reduction of information richness in the structured approach did not lead to a sacrifice for decision quality. They found that facilitated groups did reach higher quality decisions than user-driven groups, possibly due to the fact that the formal structure via imposed meeting agenda encouraged the groups to consider the issues more carefully. They also observed that in groups in which an informal leader emerged during the experiment, the leader played a crucial role in leading the group to its final decision.

Dickson et al. (1993) compared three different levels of facilitation in GSS; (1) User-driven mode with no facilitation support wherein all the system features and functions are available to group members and they can fully use them in any way and in any order; (2) Chauffeur-driven mode wherein a chauffeur, at the direction of the group, implements the system features and functions, without affecting the group process; (3) Facilitator-driven mode when following a predefined script, a facilitator actively involves in the group process and guides the group to use the technology. The facilitator-driven groups had lower level of post-meeting consensus than the groups with only technical, unscripted support, because groups resisted the structure imposed by the facilitator. On the other hand, user-driven groups had lower level of post-meeting consensus than either chauffeur-driven groups or facilitator-driven groups. This study suggests that a form of guidance is needed for groups to make a good quality decision but groups should be given some rooms and flexibility for adapting to the formally facilitated structure to reach a consensus on their decisions. Anson et al. (1995) investigated the effect of facilitation (unscripted facilitation) and GSS on the performance, cohesion and process. Their findings suggested that facilitated groups perceived improved group process and greater cohesion but GSS groups did not. But no effect of treatment on performance was found. Wheeler and Valacich (1996)'s study investigated the role of facilitation as an appropriation mediator to guide and restrict groups. They found that facilitation increased groups' faithful use of structured decision procedures and that faithful appropriation resulted in improving decision quality. In their experiment, the facilitators provided guidance by reminding the group the heuristic or provided restrictiveness by interjecting verbal comments when the group tried to unfaithfully appropriate the heuristic. Even though the role of facilitators was limited in providing guidance or restrictiveness without using a rigid script or in helping the groups overcome procedural or relational overcome, facilitation was more influential than the other two appropriation mediators—GSS and training .

Two studies (Limayem et al., 1993; Wong and Aiken, 2003) compared the effectiveness of automated facilitation and human facilitation using an external facilitator and both studies found that automated facilitation is as effective as human facilitation. Limayem et al. (1993)'s study found that automated-facilitated groups as well as human-facilitated groups achieved a significantly higher level of consensus and decision quality than unaided groups. Also they found that automated facilitation is as effective as human facilitation in both measures. Wong and Aiken (2003) found that in terms of process satisfaction, cohesiveness, GSS ease-of-use, perceived effectiveness and number of ideas, automated facilitation mode was as effective as expert-facilitator support mode and more effective than novice-facilitator support mode.

Besides an external facilitator, a group leader sometimes plays facilitative roles. Hiltz et al (1991) and Ho and Raman (1990) investigated the interaction effects between structures supported by GSS and facilitation by group leaders. Hiltz et al. (1991) found that designated leaders helped groups achieve consensus. On the contrary, Ho and Raman's (1991) found that neither GSS nor elected leadership did increase the consensus.

Both of the studies found significant interaction effects between structures supported by GSS and leadership; the effects of GSS feedback and leadership canceled out each other in increasing the level of consensus (Hiltz et al, 1991) and a leader in a GSS group had less influence than the one in a non-GSS (Ho and Raman, 1991). However this negative interaction effect was not found in case of an external facilitation. Anson et al. (1995) found that an external facilitator and GSS support were more effective on cohesion and process when provided together than when provided separately –their effects were additive. In their further analysis, experiences and attitudes toward GSS of facilitator and participants, as well as GSS tool restrictiveness were identified as important factors moderating the combined effects of facilitation and GSS. On the contrary, neither negative nor positive interaction effect between GSS and external facilitator support was found in Miranda and Bostrom's study (1999).

Miranda and Bostrom (1999) investigated the effectiveness of two different facilitation targets (process facilitation and content facilitation), in terms of perceived meeting processes (relationship development, participation, issue-based conflict, interpersonal conflict, and negative socioemotional conflict), satisfaction, and decision quality. The result suggests that process facilitation improved meeting processes, while content process deteriorated it. Meeting processes had a positive impact on satisfaction but no impact on decision quality. Even though no separate effect of facilitation was investigated, Reagan-Cirincione (1992) found that the combined use of human facilitation, decision modeling and information technology improved the performance of small, interacting groups so that they performed significantly better on cognitive conflict tasks than their most capable member.

Several studies were done in GSS to investigate the effectiveness of specific process structuring techniques. Niederman and DeSanctis (1996) compared Structured-Argument Approach and NGT in synchronous GSS environment. They found Structured-Argument Approach led to a greater combination of coverage of critical issues and consensus on the problem definition, higher satisfaction with the problem definition, and higher commitment to implementing results of the group meeting. In asynchronous environments, three experiments were conducted to compare different process structuring techniques, Dialectical Inquiry approach vs. Constructive Consensus approach (Fjermestad et al., 1995), argumentation and structured communication approach vs. no structure (Ocker et al., 1995/1996) and Parallel coordination vs. Sequential coordination (Kim et al., 1998). None of these studies found significant differences between different approaches.

Table 2.4 summarizes the findings of the studies mentioned in the above. In sum, in synchronous GSS, facilitation may help groups generate more unique ideas and achieve better decision and consensus. However, less restrictive facilitation approach seems to work better in synchronous GSS environment (Dickson et al., 1993; George et al., 1992) and automated facilitation was found as effective as human facilitation (Limayem et al., 1993; Wong and Aiken, 2003). Except the effect of designated leadership (Hiltz et al., 1991), no significant effect of structured facilitation was found in asynchronous GSS environment. Since asynchronous group communication environment has vastly different group dynamics and coordination modes than the synchronous GSS environment, facilitation might also have different effects. Due to its asynchronicity and parallelism, asynchronous group communication has difficulty in coordinating group members' contributions. Facilitation supports—enforcing structured process or providing human or computer facilitations— could help by indirectly informing the group members "where they are now" and "where they are heading for" or directly enforcing formal procedures (Hiltz et al., 1996). New Jersey Institute of Technology conducted a series of control experiments testing the effectiveness of the use of different process intervention techniques in asynchronous environments but did not find significant results (Hiltz et al., 1996). However, they reported wrong choice of tasks or inappropriate implementations of process interventions as possible cause of the resulting insignificances. Furthermore, the current study (Dowling and Louis, 2000) showing the superiority of asynchronous CMC based NGT implementation over its face-to-face counterpart, in terms of quantity and quality of ideas generated, as well as decision time, suggests the potential advantage of structured discussions in asynchronous CMC.

Table 2.4 Previous Empirical GSS Studies on Facilitation

Study	Independent Variable	Dependent Variable	Task and Group Size	Source	Target	Outcome
Synch. GSS						
Ho and Raman (1991)	GSS X Elected leader	Consensus Influence of the leader	Preference task (Foundation task), 5 members	GSS vs. Elected Leader	Process facilitation (facilitation by a group leader)	(1) Neither GSS nor leadership increases consensus (2) GSS support decreases influences of leader
George et al. (1992)	Facilitation vs. No facilitation	No. of alternatives, decision quality, Consensus, satisfaction	Creativity + Intellective task, 4-5 members	External facilitator with GSS support	Process facilitation (scripted facilitation with agenda)	(1) No significant difference (2) With No. of alternatives as covariates; facilitated groups made better decision and unfacilitated groups are more likely to reach consensus
Dickson et al. (1993)	Restrictive facilitation vs. Less-restrictive (Chauffeured) facilitation vs. No facilitation	Consensus,	Preference task (Foundation task), 3-6 members	External facilitator with GSS support	Process facilitation (unscripted facilitation) vs. Technical Assistance	Consensus was higher for chauffeured groups followed by facilitated and unfacilitated groups
Limayem et al. (1993)	Human facilitation vs. Automated facilitation	Consensus, Decision Quality	Preference task (Foundation task), 3-6 members	External facilitator with GSS support	Content facilitation (active decision guidance)	(1) For consensus and decision quality, facilitated groups performed better than unfacilitated groups (2) Automated facilitation is as effective as human facilitation
Reagan-Cirincione (1992)	Human facilitation with decision modeling and computer supports vs. No facilitation	Accuracy of judgment	Cognitive conflict tasks, 4-5 members	External facilitator with decision models and computer supports	Process facilitation (unscripted facilitation) and Content (active decision guidance)	Facilitated groups made more accurate judgments than their most accurate members.

Table 2.4 Previous Empirical GSS Studies on Facilitation (Continued)

Study	Independent Variable	Dependent Variable	Task and Group Size	Source	Target	Outcome
Anson et al (1995)	GSS X Facilitation	Performance, Cohesion, Perceptions to group process	Planning task, 6-7 members	External facilitator with or without GSS support	Process facilitation (unscripted facilitation after proper facilitator training)	(1) No difference on performance. (2) Facilitated groups improved cohesion and group process while GSS groups did not. (3) Combined effects of facilitation and GSS were additive (4) Quality of facilitator and restrictiveness of GSS tools are moderating factors for combined effects of facilitation and GSS.
Niederman and DeSanctis (1996)	Structured-Argument approach vs. NGT	Information search, Equivocality reduction, Consensus, Critical issues, Consensus + Critical issues, Perceived quality, Process satisfaction, Decision time, Implementation	Creativity, Decision-making task, 3-8 members	Instructions on process structures were given, No human / automated facilitation.	Process Facilitation (comparing different process structures)	(1) Structured-Argument Approach led to a greater combination of coverage of critical issues and consensus on the problem definition. (2) Structured-Argument Approach led to a higher satisfaction with the problem definition. (3) Structured-Argument Approach led to a greater commitment to implementing results of the group meeting.
Wheeler and Valacich (1996)	Facilitation X GSS configuration X training	Faithful and Unfaithful use of heuristics, Decision Quality	Decision-Making (hidden profile) task, 5 members	External facilitator with or without GSS support	Process facilitation (unscripted facilitation with verbal comments regarding the heuristic)	(1) Facilitated, Level 2 GSS, Trained groups more closely followed the heuristic than unfacilitated, Level 1 GSS, Untrained groups (2) Faithful use of the heuristic improve decision quality, while unfaithful use of the heuristic harmed decision quality

Table 2.4 Previous Empirical GSS Studies on Facilitation (Continued)

Study	Independent Variable	Dependent Variable	Task and Group Size	Source	Target	Outcome
Miranda and Bostrom (1999)	GSS X Process facilitation vs. Content facilitation	Meeting Process, Satisfaction Decision Quality	Decision-Making tasks, 5-8 members	External facilitators with or without GSS support	Process facilitation (scripted facilitation with agenda)	(1) Process facilitation improved meeting processes (2) Content facilitation harmed meeting processes (3) No interaction effect between facilitation and GSS (4) Meeting processes increased satisfaction, but no impact on decision quality
Wong and Aiken (2003)	Expert-human vs. Novice-human vs. Automated facilitation	Group Process (Satisfaction, Cohesion, GSS ease-of-use, Perceived effectiveness) Outcomes (Number of unique ideas, Number of unique quality ideas)	Creativity task (University parking problem), 10 members	External facilitators with GSS support	Process facilitation (unscripted facilitation) and Technical Assistance	Automated facilitation is as effective as expert-human facilitation and more effective than novice-human facilitation in terms of group process and outcome.

Table 2.4 Previous Empirical GSS Studies on Facilitation (Continued)

Study	Independent Variable	Dependent Variable	Task and Group Size	Source	Target	Outcome
Asynch. GSS						
Hiltz et al. (1991)	Statistical Feedback (SF) X Designated Leadership (DL)	Consensus, Decision quality, Satisfaction	5 members	GSS vs. Designated Leader	Process facilitation (facilitation by a group leader)	(1) DL increases consensus, (2)SF and DL cancel out each other's effect in consensus, (3)SF alone without DL undermines decision quality
Fjermestad et al. (1995)	Dialectic Inquiry (DI) X Constructive Consensus (CC)	Decision quality, Depth of evaluation, Efforts	Planning task, 4-7 members	Asynchronous GSS, External facilitator, Group Leader given to all conditions	Process Facilitation (comparing different process structures)	(1)No significant findings on decision quality and depth of evaluations (2) DI groups expended more efforts than CC groups.
Ocker et al. (1996/1997)	IBIS approach vs. no structure X Asynchronous GSS vs. face-to-face	Quality of solutions, Creativity of solutions	Creativity task, 4-7 members	Asynchronous GSS, External facilitator, Group Leader given to all conditions	Process Facilitation (comparing structure with no structure)	(1) No differences in terms of structure (2) Asynchronous GSS produced more creative solutions than face-to-face meetings.
Kim et al. (1998)	Less restrictive (Parallel) coordination vs. More restrictive (Sequential) coordination X Leader vs. No leader	Decision quality, Decision satisfaction, Process satisfaction	Intellective Decision-making task, 3-5 members	Asynchronous GSS, External facilitator, Group Leader given to all conditions	Process Facilitation (comparing different coordination approaches)	(1) Coordination methods led no significant differences on decision quality. (2) Parallel coordination led higher process satisfaction than sequential coordination. (3) Groups made better quality decision and were more satisfied with process when facilitated by leaders.

2.6 Chapter Summary

This chapter identifies the process gain and losses as the main factors to determine the meeting productivity. Among various process losses, two blocking effects were identified, production blocking and cognitive interference. Production blocking plays the major role in determining the meeting productivity in synchronous meetings. Since most of the empirical studies on the meeting productivity of different sized groups were done in synchronous communication mode, the focus on their studies was on the effect of production blocking. The previous GSS empirical studies on the group size found that large groups produced more total unique ideas than small groups in synchronous decision room environments. But large groups had more production blocking as well. The diversity of the participants' backgrounds or the knowledge matter more than the mere increase in group size. A strong interaction effect found between the group size and GSS tells more about the process of synchronous meetings; large groups benefit more from the use of GSS in producing total or per person unique ideas than small groups. This interaction effect is expected in synchronous meeting environments where participants share their time of contributions, since the severe effect of production blocking in large groups can be reduced in a greater extent by the use of GSS. Cognitive interference is the effect that a person is interfered by the exposure to other persons' ideas before he/she produces their own. Different from the production blocking effect, that is not a major issue in asynchronous meetings, cognitive interference could determine the productivity of both synchronous and asynchronous meetings. However, no GSS empirical studies were done to investigate this issue.

In Section 2.2, the asynchronous meeting was defined as a unique form of meeting distinguished from any meeting in synchronous communication environments. Those unique characteristics were discussed based on the Media Synchronicity Theory. Among the five characteristics of the Media Synchronicity Theory, immediacy of feedback and parallelism complement to each other in a sense that the asynchronous meetings has higher level of parallelism because of the lower demand of immediacy of feedback. Several challenges in asynchronous meetings were discussed.

Section 2.3 identified process structuring as one of the possible solution to improve the meeting productivity. Several process intervention techniques to structure the meeting process including brainstorming, NGT and Delphi were discussed. Among those techniques, Delphi is the only technique supporting asynchronous meetings. Even though Delphi was used for collecting expert opinions in various applications, the effects of Delphi in structuring the meeting process were not well known or well tested. The computer-based implementation of the Delphi makes this technique evolve as an asynchronous meeting process.

In the GSS area, structuring meeting processes were done in the form of facilitation. Theoretical aspects of facilitation and the previous empirical GSS studies on facilitation were discussed in Section 2.4. In general, facilitation supports tend to improve the meeting productivity and decision quality of the synchronous GSS groups. However less restrictive approach was more effective in synchronous GSS meetings. Some empirical studies comparing asynchronous meetings or virtual teams with face-to-face meetings show that this new form of meetings is more effective than face-to-face meetings in some aspects of decision making and applications. However asynchronous meetings is a unique form of meeting with distinctive purpose and uses. Therefore to improve the productivity of this new form of meetings, more research efforts should be exerted in the investigation of the effective structure of facilitation supports in asynchronous meetings.

CHAPTER 3

RESEARCH FRAMEWORK AND HYPOTHESES

The purpose of this chapter is to draw the research questions from the literature review discussed in Chapter 2 and discuss the hypotheses to be tested in this study. Section 3.1 discusses the rationale of this study from the literature review in Chapter 2, and identifies the research questions and framework. Section 3.2 discussed the hypotheses and their rationale.

3.1 Research Questions and Framework

Previous empirical studies on synchronous GSS meetings found that large groups produced more total ideas than small groups but have more production blocking as well. EBS groups produced more total ideas than face-to-face groups with no computer support. However the results of those studies do not clear show the superiority of EBS over other idea generation processes such as nominal idea generation. One experiment even showed that a simple computer editor could improve the idea generation productivity of face-to-face groups without changes in their process. All of these findings led the investigation of the effect of the process on the idea generation productivity without confounding with the effect of computer use. Also more investigation of the effect of group size on the number of per person idea is needed.

The literature review in Chapter 2 reveals that the asynchronous meeting is an unique form of meeting different from the face-to-face meeting or the synchronous GSS meeting, which incorporates distinctive situations and purposes. However, previous empirical studies more focused on the comparison of asynchronous meetings vs. face-to-face meetings and the focus of research should be shifted more to the efforts of improving this unique form of meetings. Moreover, since the asynchronous meeting is distinctive from the synchronous meeting, different effects of process gains / losses are expected on the different-sized asynchronous groups. Even though previous studies identify several challenges in asynchronous meetings and these challenges are due to the process losses, those effects were not still clearly investigated.

Various process structuring techniques were developed to improve the meeting productivity by enhancing the potential process gains / losses. A few empirical studies have been done to investigate the question of "Does process structuring improve the productivity of asynchronous meetings?" However, those studies did not find significant results because of the difficulty in controlling asynchronous groups or the improper choice of tasks. Therefore further investigation of this issue is still needed with more proper treatment of structures and tasks.

Delphi has been used to provide a facilitated process to collect the opinions from the geographically and temporally dispersed experts. However, the current paper and pencil Delphi is not flexible enough that varied structures could be implemented. From this reason, the Delphi structure was not clearly defined or not properly implemented in the previous empirical studies which investigated the question of "Does Delphi work?" However, the validity of those studies was questioned because of lack of standard or incomparability among different studies. The computer-based Delphi implementation makes Delphi a distinctive facilitated structure which can be used in asynchronous meetings and the use of this structure would help answer the question of "Why or How does Delphi work?"

From the above reasons, this study focuses on investigating following research question:

- How does a facilitated structure support (Delphi structure in this study) affect asynchronous group communications?
- Does group size influence the effectiveness and the satisfaction of asynchronous group communications?
- How do the process gains / losses affect the effectiveness and the satisfaction of asynchronous group communications?
- What interaction effects occur between the structure and the group size?
- What are the correlations between the process gains / losses and the effectiveness or the satisfaction of asynchronous group communications?

Specifically, this study is designed to investigate the effect of Delphi structure on small and medium-sized group asynchronous group communications. Figure 3.1 represents the conceptual framework of this study.

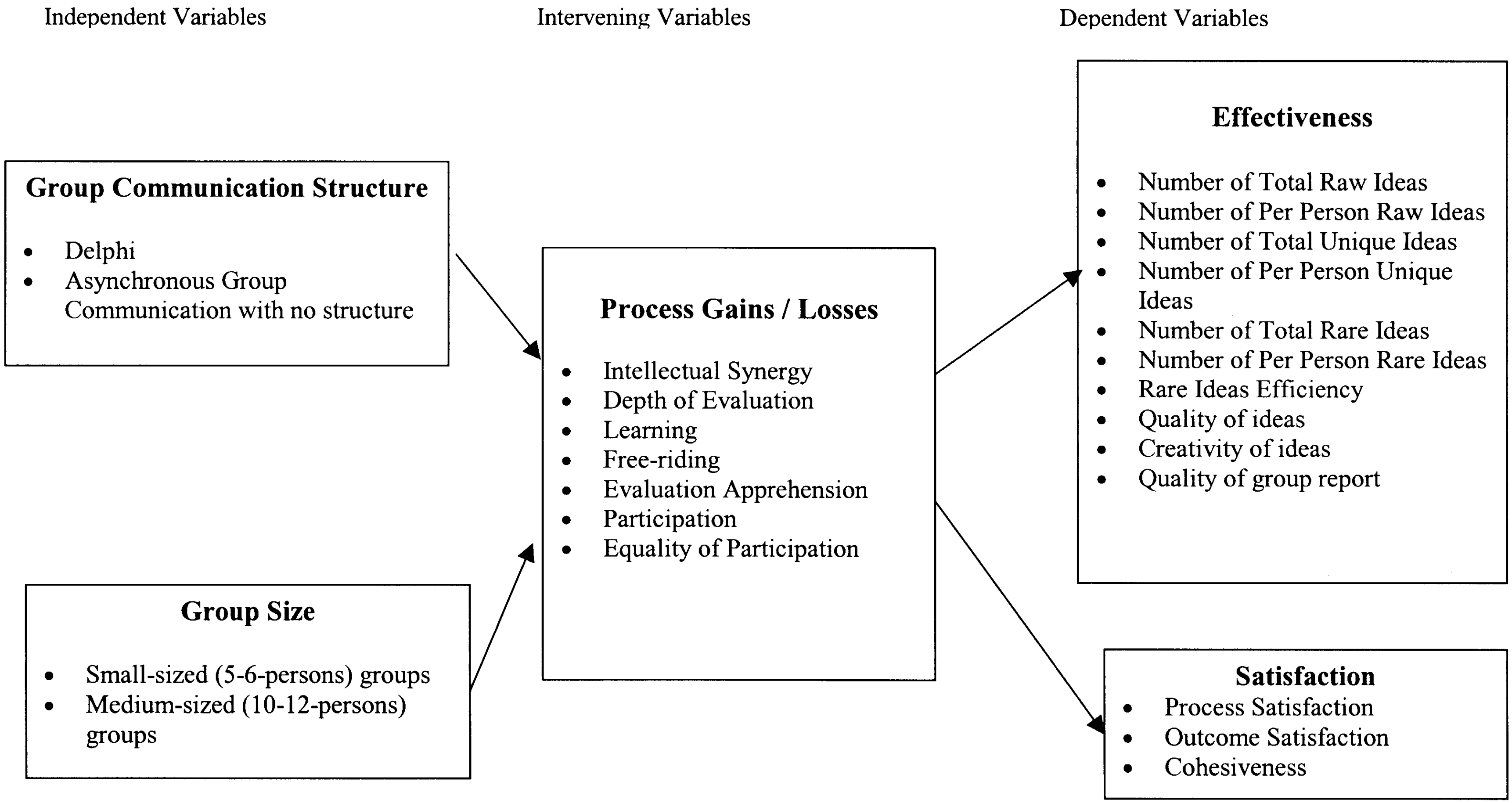

Figure 3.1 Framework of the study.

3.2 Hypotheses

3.2.1 Process Gains / Losses

There were two studies that concerned on synergy (stimulation) effects in the context of Computer-Mediated Communications. Dennis and Valacich (1993) found that electronic brainstorming groups have higher synergy effect than non-electronic counterparts. But they found no synergy effect differences between different group sizes. In addition to the case of face-to-face groups, electronic brainstorming groups did not always perform significantly better than electronic nominal counterparts and this tendency is more severe in small electronic brainstorming groups (Roy and Gauvin, 1996; Pinsonneault et al., 1999). From the above findings, we can conclude that EBS does not provide the full level of intellectual synergy.

No GSS study has shown significant results of different group size on intellectual synergy. Especially, the only EBS study investigating the effect of group size on the unique number of ideas per person and the perceived synergy (stimulation) (Dennis and Valacich, 1993) did not show significant result. However, since this study uses asynchronous communication medium wherein group members could create more creative ideas by fully reflecting their own thinking process without time pressure (Ocker et al., 1995/1996), large groups that pool more diverse knowledge and perspectives are expected to have a higher level of intellectual synergy than small groups because they have more opportunities to uncover and rethink hidden assumptions.

Delphi structure groups differ from unstructured groups in timing of feedback. Delphi structure provide each group member time and opportunity to engage in reflection (search) and force them to record their thoughts (Van de Ven and Delbecq, 1974) for a certain period of time without being interfered or evaluated by others. The review of previous research showed that getting evaluation or feedback in the early phase of idea generation could harm the effectiveness and creativity of the idea generation process (Hill, 1982; Van de Ven and Delbecq, 1974). The results of the two studies showed the importance of timing of group feedback. Roy and Gauvin (1996) found that the EBS groups that were given feedback at the end of idea generation generated more unique ideas than the EBS groups that were given constant feedback. Sosik and Avolio (1998) also found that introducing intellectual stimulating behavior, such as questioning or evaluating ideas, in the early idea generation phase tended to inhibit creative thinking processes. These findings are consistent with the previous researcher's (Hill, 1982; Van de Ven and Delbecq, 1974) belief that it is more effective for individuals to generate ideas alone without getting evaluation or feedback in the early phase of idea generation. After a full deliberation process, the Delphi group members are given summarized feedback of what other group members think about the issues. On the contrary, members in the unstructured group are given constant feedback from other group members while he/she is generating his/her own ideas. Constant feedback might have a "focus" effect wherein a group might pursue a single train of thought for long periods (i.e., cognitive inertia) (Pinsonneault et al., 1999; Van de Ven and Delbecq, 1971; Voelker, 1976) and reach a premature closure to the alternative search process and decision-making before considering all possible alternatives. Moreover, in asynchronous group communications, constant feedback would be more confusing because of the long time lag between posting and replying and the constant visibility of parallel entries. Delphi structure delays feedback until aggregation of group contributions form a meaningful body of knowledge collecting diverse points of views. Furthermore, each group member will have opportunities to add more ideas after seeing group feedback and thus this opportunity is expected to enhance intellectual synergy.

It may be more difficult to coordinate activities of group members in large groups. Uncoordinated group process might increase the cognitive burdens of the group members (Ocker et al., 1995/1996) and it would be difficult for a group member to be stimulated by ideas generated by others. Bouchard and Hare (1970) showed that in a face-to-face condition, the marginal increase in the number of unique ideas gained through addition of one group member decreases more rapidly in unstructured (interacting) groups than in nominal groups. This is because it is more difficult to coordinate the individual works of an individual group member in an unstructured group when it is overcrowded. Therefore, structured approach of Delphi providing a higher level of coordination in group decision-making process would be more beneficial to large groups in terms of intellectual synergy. For the reasons above, the following hypotheses were constructed.

H1a. The Delphi groups will perceive a higher level of intellectual synergy than the unstructured asynchronous groups.

H1b. The medium-sized groups will perceive a higher level of intellectual synergy than the small-sized groups.

H1c. Communication structure interacts with group size so that the medium-sized Delphi groups will perceive disproportionately higher level of intellectual synergy than the small-sized Delphi groups.

Delphi structure separates the evaluation stage from the idea generation stage and this separation could increase focus of decision-makers in evaluating ideas. Under The Delphi condition, evaluations will be gathered and provided as a form of controlled feedback which equally reflects the opinions of each member. However, when ideas are evaluated in an unstructured way it is more likely to reflect the most vocal or dominating minority opinion. Diverse viewpoints from a large number of people provide more opportunities for existing ideas to be critically re-evaluated or to generate alternatives. However, it is more difficult to retrieve those diverse opinions from all members without imposing a communication structure. For the reasons above, the following hypotheses were constructed.

H2a. The Delphi groups will perceive a higher level of ***depth of evaluation*** *than the unstructured asynchronous groups.*

H2b. The medium-sized groups will perceive a higher level of depth of evaluation than the small-sized groups.

H2c. Communication structure interacts with group size so that the medium-sized Delphi groups will perceive disproportionately higher level of depth of evaluations than the small-sized Delphi groups.

Computer-mediated communication has been shown to be an effective means of learning (Hiltz, 1995). Alavi (1994) showed that GDSS enhanced collaborative learning by facilitating active construction and development of emergent knowledge during group communication. Asynchronous group communication medium is not rich enough to provide immediate feedback (Daft and Lengel, 1986) and therefore individuals may have difficulty in conveying the context and meaning of information. Delphi structure delays feedback until aggregation of group contributions form a meaningful body of knowledge. This structure allows individuals to be exposed to different perspectives and opinion of others in a systematic manner, resulting in facilitating formation and modification of mental models. A large group generates more information and alternatives than a small group and members of a large group are more likely to be exposed to diverse points of view. However, without imposing a communication structure, a large volume of information and expressions of diverse points of view could overwhelm members of large groups and thus reduce the learning effect. For the reasons above, the following hypotheses were constructed.

H3a. The Delphi groups will perceive a higher level of ***learning*** *effect than the unstructured asynchronous groups.*

H3b. The medium-sized groups will perceive a higher level of learning effect than the small-sized groups.

H3c. Communication structure interacts with group size so that the medium-sized Delphi groups will perceive disproportionately higher level of learning effect than the small-sized Delphi groups.

Increase in group size should increase dispensability and decrease identifiability. Therefore, large groups are expected to suffer more from free-riding than small groups. However, Dennis and Valacich (1993) investigated the effect of technology and group size on the perceived free-riding effect, but did not find any significance on either dimension. Cooper et al. (1998) found that anonymous EBS groups perceived higher level of free-riding than identified EBS groups. However, Roy and Gauvin (1996) stated in their literature review that anonymity was neither necessary nor sufficient to induce social loafing. Roy and Gauvin (1996) investigated the effect of feedback (computer-supported nominal groups without public screen, computer-supported nominal groups with public screen at the end of the idea-generation process, and EBS groups with public display throughout the task). They found that the method of providing feedback had significant effect on the performance of members (the number of unique ideas)—feedback at the end condition is the most effective and no feedback condition is the least effective. They also found that in no feedback condition, the increase in group performance (the number of unique ideas) does not parallel increases in the total number of ideas, as is typically measured in social loafing studies. A more surprising finding was that providing feedback at the end of idea generation had the similar effect of reducing social loafing effect as constant feedback did. Members of unstructured asynchronous groups are given constant and immediate feedback about performance of other members, while members of Delphi groups are given feedback at the end of idea generation. Silent individual contributions in The Delphi condition would increase the perceived uniqueness of each individual's own contribution and enhance the sense of responsibility and commitment to the search process. Furthermore, by recording ideas in his/her own private space (i.e., private conference), more salient feedback could be given to each individual regarding the performance of his / her own performance, as well as the performance of others. Delphi structure is expected to reduce disproportionately more free-riding effects in the medium-sized groups that could break down more easily without any communication structure support. For the reasons above, the following hypotheses were constructed.

H4a. The Delphi groups will have a lower level of ***free-riding*** *than the unstructured asynchronous groups.*

H4b. The small-sized groups will have a lower level of free-riding than the medium-sized groups.

H4c. Communication structure interacts with group size so that the medium-sized Delphi groups will have disproportionately lower level of free-riding than the small-sized Delphi groups.

Previous EBS studies showed face-to-face groups have higher evaluation than electronic groups and nominal groups have higher evaluation apprehension than interacting groups. Due to the nature of nominal contribution of Delphi structure, Delphi groups are expected to fear evaluation more. Despite general belief of the effect of group size on evaluation apprehension, previous EBS studies did not find any significant effect of group size. Asynchronous communication environment is different from face-to-face communication in a sense that individual contribution is more salient and accessible to other members at any time because it is recorded in the computer system. Any member could evaluate ideas put forth by others at any time. Furthermore, both contribution and evaluation will be permanently recorded in the computer and can be accessed at any time. Since this study is conducted in asynchronous group communication environment, it is expected there may be different effect on evaluation apprehension than in the face-to-face environment. Due to the nature of asynchronous medium, identifiability in asynchronous groups is higher than that in their face-to-face counterparts. Therefore, in an asynchronous environment, members in a large group are likely to have more evaluation apprehension than members in a small group. For the reasons above, the following hypotheses were constructed.

H5a. The Delphi groups will perceive a higher level of evaluation apprehension than the unstructured asynchronous groups.

H5b. The medium-sized groups will perceive a higher level of evaluation apprehension than the small-sized groups.

One of the important objectives of meeting facilitation is to provide appropriate structures and supports to promote active participation of group members. The members in The Delphi condition are asked to complete a series of sub-tasks in different phases, such as the idea generation phase, the consequence development phase, and the voting phase. Facilitated supports clearly remind the members what they should do in each phase, and this goal-directed or task-oriented approach of Delphi is expected to promote more participations. In terms of the effect of group size, Dennis et al. (1990) found that there were no statistically significant differences in perceived participation among groups with different sizes. They also found that in average, members of large groups posted more comments and typed more characters ($p<0.052$) than members in small groups. It is speculated that this lack of difference in participation of different sized groups might be due to the effect of production blocking in synchronous environments. Synchronous contributions are converged into the limit as the members compete with each other for a turn to speak. However in asynchronous group communication environments wherein production blocking has little effects, the more people involve in discussion, the more participation (i.e. the number of words said or the number of contributions done) the group should have. In terms of per person word count, the small-sized groups will be superior to the medium-sized groups because smaller groups will have lower free-riding effects. Therefore,

H6a. The Delphi groups will participate more in discussion than the unstructured asynchronous groups.

H6b. The medium-sized groups will participate more in discussion than the small-sized groups.

H7a. A person in a Delphi group will participate more in discussion than a person in an unstructured asynchronous group.

H7b. A person in a small-sized group will participate more in discussion than a person in a medium-sized group.

The role of the group coordinator is to distribute / coordinate the work of group and to make sure the group completes the task on time. The group coordinators of the unstructured groups will make more efforts to facilitate the group work since their groups do not have the facilitation supports which are given to Delphi groups. As the group size increases, the more coordinating work will be needed and an unstructured group that does not have the facilitation support is likely to break down more severely from process losses as its group size increases.

Therefore,

H8a. The group coordinator in an unstructured asynchronous group will participate more in discussion than the group coordinator in a Delphi group.

H8b. The group coordinator in a medium-sized group will participate more in discussion than the group coordinator in a small-sized group.

H8c. Communication structure interacts with group size so that the group coordinator of the medium-sized unstructured groups will participate disproportionately more in discussion than the group coordinator of the small-sized unstructured groups.

Previous researchers found that computer mediated communication generally allows more equal participation and reduces negative effects from dominance of majority opinion holders (Dubrovsky et al., 1991; Siegel et al., 1986; Straus, 1997; Weisband, 1992). Due to the enforced individual contribution, members of Delphi groups are expected to participate more in group discussion regardless of their status or personal predisposition because this structure facilitates equal opportunity for every member to express his/her opinion on the issue. Since small-sized groups tend to have less free-riding than medium-sized groups, the members in a small-sized group are expected to participate more equally than the members in a medium-sized group. The individual idea generation phase of Delphi will make members in medium-sized groups much more equally participate comparing to members in small groups who might feel higher commitment to contribute their own efforts anyway. From the above reasoning,

H9a. The unstructured asynchronous groups will participate in discussion less equally than the Delphi groups.

H9b. The medium-sized groups will participate in discussion less equally than the small-sized groups.

H9c. Communication structure interacts with group size so that the small-sized Delphi groups will participate in discussion less equally than the medium-sized Delphi groups.

3.2.2 Effectiveness

To date, there is only one Delphi experiment specifically investigating the effectiveness of Delphi structure in idea generation task: Van de Ven and Delbeq (1974) found that Delphi groups generated more unique ideas than non-structured interacting groups but both groups did not differ significantly in terms of their satisfaction. In their review papers, Van de Ven and Delbecq (1971) stated that based on the three measures of performance (the number of unique ideas per person, the mean total number of ideas, and the quality of ideas produced), nominal groups (groups wherein each groups member generates ideas alone without interacting with other members) have been found significantly superior to interacting groups. Even in Electronic Brainstorming Systems (EBS) research, nominal brainstorming groups have been found as productive (i.e. in terms of number of unique ideas) as EBS groups wherein group members interact each other (Hymes and Olson, 1992; Pinsonneault et al., 1999).

Nominal contributions without evaluations in the early phase of idea generation and controlled feedback in Delphi groups would produce more unique ideas than the free-formed contributions in unstructured asynchronous groups because group members are more likely to commit to the search process due to the silent generation of ideas—the evidence of search activity (Van de Ven and Delbecq, 1971). This silent idea generation phase would allow group members to fully reflect on the problem without interference from contribution of others. This process allows individuals to fully search all possible alternatives. Previous research on free-riding, social loafing and social matching showed that constant feedback could harm the effectiveness of the group by setting a lower norm of performance in the early stage of group process. It is therefore more effective to provide group feedback after each individual fully considers and searches his/her own alternatives. Especially in asynchronous communication mode wherein contribution and feedback are dispersed in time, imposing such a communication structure would help groups to coordinate their efforts in more effective way. Therefore, it is expected that Delphi groups are likely to perform better in terms of quantity and quality than unstructured asynchronous groups.

Previous GSS studies showed the relative superiority of large groups in terms of the number of unique ideas produced to small groups (See Table 2.2). However, most of previous GSS research on group size did not investigate the effects of group size in terms of number ideas per person. Dennis and Valacich (1993)'s experiment is the only one which reported this effect but they also did not find main effects of group size on per person performance. However, they reported an interaction effect between the effect of group size and technology: Large (12 members) groups had more benefits of computer support than small (6 members) groups, in terms of per person ideas. From this finding, we could infer that imposing a structure [1] could make differences in per person performance of different sized groups. Van de Ven and Delbecq (1971) also stated that as the group size increases, the superiority of structured groups such as Delphi or NGT groups increases in terms of total number of unique ideas and the quality of ideas produced because structured group processes can accommodate large number of participants without dysfunctions of large group discussion. In other word, structured

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[1] In this case, this was a technology structure, not a communication structure. However, we could assume that technology will impose a kind of structure to group communication after all.

discussion would be more effective for large groups which need a higher level of group coordination efforts. Even though previous research did find clear main effects of group size on per person performance, we expect small groups would produce more unique ideas per person than large groups, if we apply the same logic behind the hypothesis on the effect of group size on the level of free-riding / social loafing.

Previous GSS studies also showed that large groups produce better quality of ideas than small groups (See Table 2.2) and this tendency could be well explained by the expected effects of process gains such as intellectual synergy and learning.

For the reasons above, the following hypotheses were constructed.

H10a. The Delphi groups will produce more ***total raw ideas*** *than the unstructured asynchronous groups.*

H10b. The medium-sized groups will produce more total raw ideas than the small-sized groups.

H10c. Communication structure interacts with group size so that the medium-sized Delphi groups produce disproportionately more total raw ideas than the small-sized Delphi groups.

H11a. The Delphi groups will produce ***more total unique ideas*** *than the unstructured asynchronous groups.*

H11b. The medium-sized groups will produce more total unique ideas than the small-sized groups.

H11c. Communication structure interacts with group size so that the medium-sized Delphi groups produce disproportionately more total unique ideas than the small-sized Delphi groups.

H12a. The Delphi groups will produce more ***per person raw ideas*** *than the unstructured asynchronous groups.*

H12b. The small-sized groups will produce more per person raw ideas than the medium-sized groups.

H12c. Communication structure interacts with group size so that the medium-sized Delphi groups produce disproportionately more per person raw ideas than the small-sized Delphi groups.

H13a. The Delphi groups will produce more ***per person unique ideas*** *than the unstructured asynchronous groups.*

H13b. The small-sized groups will produce more per person unique ideas than the medium-sized groups.

H13c. Communication structure interacts with group size so that the medium-sized Delphi groups produce disproportionately more per person unique ideas than the small-sized Delphi groups.

H14a. The Delphi groups will produce ideas of higher ***importance*** *than the unstructured asynchronous groups.*

H14b. The medium-sized groups will produce ideas of higher importance than the small-sized groups.

H14c. Communication structure interacts with group size so that the medium-sized Delphi groups will produce ideas of disproportionately higher importance than the small-sized Delphi groups.

An individual's unique experience or knowledge that is distinct from that of others could generate novel or creative ideas. Therefore, in order to enhance creativity of individuals, group communication structure should be in a form of stimulating the intellectual ability of the individual, without inhibiting or limiting individual information search process. In order to enhance creativity, individuals need enough time to reflect on their own information search and recall without being interfered or swayed by others. This belief was confirmed by one study (Ocker et al., 1995/1996) that found asynchronous groups to be more creative than their face-to-face counterparts. When a person is exposed to other person's ideas before he/she generates their own ideas, he/she would more exert more on convergent thinking, rather than divergent thinking. This might inhibit a group from producing more creative or novel ideas.

Individuals also could benefit from group process. They are able to spark more ideas with better quality and creativity from the ideas generated by others (intellectual synergy). In order to achieve this objective, individuals should get feedback of how other members think about the issue. Delphi structure alternates individual information process and controlled group feedback. Delphi structure allows each individual to concentrate on the reflection of his/her own knowledge or experience without being interfered by ideas of others. In this mode, it is possible to gather more novel and/or creative items by avoiding cognitive inertia wherein brainstorming groups pursue a single train of thought for long periods (Van de Ven and Delbecq, 1971; Voelker, 1976). Therefore it allows individuals to exert their full capability and creativity at individual level and allows groups to have collective synergy at group level.

Valacich et al. (1995) found that the performance (in terms of quantity and quality of ideas) of heterogeneous groups improved at a higher rate for increased group size than the performance of homogeneous groups. Creativity or novelty of ideas comes from either the unique background of the individual or knowledge or intellectual stimulation at the group level. Therefore, it is more probable for large groups produce more novel or creative ideas than small groups because large groups are more likely to pool heterogeneous backgrounds or knowledge resulting in inducing more group synergy.

For the reasons above, the following hypotheses were constructed.

H15a. The Delphi groups will produce more ***total rare ideas*** *than the unstructured asynchronous groups.*

H15b. The medium-sized groups will produce more total rare ideas than the small-sized groups.

H15c. Communication structure interacts with group size so that the medium-sized Delphi groups produce disproportionately more total rare ideas than the small-sized

Delphi groups.

H16a. The Delphi groups will produce more ***per person rare ideas*** *than the unstructured asynchronous groups.*

H16b. The small-sized groups will produce more per person rare ideas than the medium-sized groups.

H16c. Communication structure interacts with group size so that the medium-sized Delphi groups produce disproportionately more per person rare ideas than the small-sized Delphi groups.

H17a. The Delphi groups will produce ideas of higher ***creativity*** *than the unstructured asynchronous groups.*

H17b. The medium-sized groups will produce ideas of higher creativity than the small-sized groups.

H17c. Communication structure interacts with group size so that the medium-sized Delphi groups will produce ideas of disproportionately higher creativity than the small-sized Delphi groups.

Due to the separation of idea generation phase and evaluation / analysis phase, Delphi structure would allow groups to consider more possible alternatives and to evaluate each alternative more thoroughly. Because of superiority of intellectual synergy and depth of evaluation of Delphi approach, Delphi groups are likely to analyze the issue more thoroughly and provide better analysis and evaluation of the given issues than unstructured asynchronous groups.

H18a. The Delphi groups will produce better ***quality report*** *than the unstructured asynchronous groups.*

H18b. The medium-sized groups will produce better report of than the small-sized groups.

H18c. Communication structure interacts with group size so that the medium-sized Delphi groups will produce disproportionately better quality report than the small-sized Delphi groups.

3.2.3 Satisfaction

Van de Ven and Delbecq (1974) found that there is no significant difference in satisfaction between Delphi and interacting group. Rohrbaugh (1979) found that unstructured groups have higher level of process satisfaction than Delphi groups. Kim et al. (1998) found that groups with less restrictive structure tend to be more satisfied than groups with more restrictive structure. These findings suggest that imposing a communication structure does not always help to increase group satisfaction.

Computer-mediated groups are not always satisfied about their group process as compared to their face-to-face counterparts (Adrianson and Hjelmqist, 1991; Pinsonneault and Kraemer, 1989). Raman et al. (1993) reported that dispersed groups are more dissatisfied about their decision scheme than non-dispersed groups. These findings imply direct interaction among group members, such as face-to-face or non-dispersed communication mode, is helpful in increasing group process satisfaction. Pinsonneault et al. (1999) reported in their review that EBS groups have higher process satisfaction than nominal groups.

Due to the nature of moderated discussion of Delphi, Delphi groups will experience more task-oriented process than unstructured asynchronous groups. Therefore comments in Delphi communication are expected to be more goal-oriented and objective, rather than social and emotional. Delphi groups are less likely to personalize the issue that is being discussed. Moderation and controlled feedback may reduce confusion and frustration possibly introduced in asynchronous group communication.

The findings of previous GSS research on group size effect on process satisfaction are mixed (See Table 2.1). Delphi structure is likely to help large groups be more satisfied about the process because nominal contribution could facilitate equal participation and a large volume of information and opinions could be summarized in the form of controlled feedback.

H19a. The Delphi groups will have higher level of ***process satisfaction*** *than the unstructured asynchronous groups.*

H19c. Communication structure interacts with group size so that the medium-sized Delphi groups will have disproportionately higher level of process satisfaction than the small Delphi groups.

Since Delphi groups are expected to be more effective (in terms of quantity and quality of ideas) than unstructured asynchronous groups, they are also expected to be more satisfied with their works. Nominal idea generation allows individuals to search all possible alternatives than interactive idea generation. A series of nominal contribution and controlled feedback could provide every member the equal opportunity to express his/her own idea and opinions on ideas and group discussion is not likely to be dominated by a few members. Members are likely to commit more on group's decision when they consider all possible alternatives and fully express their opinions about the ideas. In this mode of discussion, quality of decision or ideas will be decided by group as a whole, not by a few members who have dominated the group discussion. Due to the nature of moderated discussion, interaction effect between communication structure and group size is also expected.

For the reasons above, the following hypotheses were constructed.

H20a. The Delphi groups will have higher level of ***outcome satisfaction*** *than the unstructured asynchronous groups.*

H20c. Communication structure interacts with group size so that the medium-sized Delphi groups will have disproportionately higher level of outcome satisfaction than the small Delphi groups.

Some aspect of group synergy comes from social facilitation (Roy and Gauvin, 1996). Individuals enjoy socializing in groups even though group interaction is not always as effective as individual problem-solving. The presence of others motivates individuals and provides more confidence in their decisions. Solving problems with other members and sharing responsibility could be more comfortable and more enjoyable than going about it alone. Delphi structure minimizes direct interaction among group members and communication and exchange of opinions is only done by controlled feedback. Therefore, it is hard to convey subtle social meaning through moderated Delphi discussion. However, subtle dynamic of social interaction can facilitate social cohesion within a group. Therefore, Delphi groups are likely to be less cohesive than unstructured asynchronous groups. However, this tendency may decrease in case of large groups because it is more difficult to convey subtle social meanings from one member to another when a group is large.

For the reasons above, the following hypotheses were constructed.

H21a. The Delphi groups will have lower level of ***cohesiveness*** *than the unstructured asynchronous groups.*

H21c. Communication structure interacts with group size so that the medium-sized Delphi groups will have disproportionately higher level of cohesiveness than the small Delphi groups.

CHAPTER 4

RESEARCH METHODOLOGY

Section 4.2 of this chapter describes the experimental design of this study. Section 4.3 describes the important features of the asynchronous group communication system (Webboard) used in this study. Section 4.4 discusses the implementation of computer-based Delphi used in this study. Section 4.5 and Section 4.6 describes the task used in the experiment and the subjects who participated in the experiment. Section 4.7 briefly discusses what was found in the pilot studies and modified by those findings. Section 4.8 presents the instruments used in this study. Section 4.9 provides a detailed account of the experiment procedure. Section 4.10 defines the measurement for the intervening and dependent variables.

4.1 Experimental Design

To test the hypotheses, a controlled experiment with a 2 (communication structure) X 2 (group size) factorial design was conducted. In order to obtain a sufficient statistical power, eleven per condition were run. Figure 4.1 below represents this experimental design. The four conditions are described as follows:

Small-sized Delphi condition includes groups of 5-6 subjects who completes the task using Delphi structure

Medium-sized Delphi condition includes groups of 10-12 subjects who completes the task using Delphi structure

Small-sized Unstructured condition includes groups of 5-6 subjects who completes the task not using Delphi structure

Medium-sized Unstructured condition includes groups of 10-12 subjects who completes the task not using Delphi structure.

Communication Structure	Group Size: *Small-sized (5-6 persons)*	Group Size: *Medium-sized (10-12 persons)*
Delphi	11 groups	11 groups
Unstructured	11 groups	11 groups

Figure 4.1 Experimental design.

In the dimension of communication structure, Delphi groups were compared to unstructured asynchronous groups. In the dimension of group size, small-sized groups (5-6 members per group) were compared to medium-sized groups (10-12 members). Size of six for small groups was chosen considering the high dropout rates in asynchronous CMC experiments. Because of the long time period (two-and-half weeks of experiment) and limited number of potential subjects who could be used in one semester, the cutoff points for group size (6 vs. 12 members) were chosen in order both to be compatible with Electronic Brainstorming studies investigating the effect of group size (See Table 2.2 for details) and to be practical in terms of obtaining sufficient subjects. Any small-sized group in which more than one member and any medium-sized group in which more than two members dropped out from the experiment was discarded from data analysis. It is not avoidable to have a buffer of group size considering high drop out rates in asynchronous CMC experiments.

4.2 Technology Used

Both the Delphi and the unstructured groups used Webboard (http://www.akiva.com/products/webboard/index.cfm) to complete the experiment task. Webboard is an asynchronous communication system in which messages are organized in a tree structure which makes one discussion thread. Discussion threads also can be organized in different conferences and the privilege for managing each discussion board or each discussion conference can be given to one or more users. The Post feature makes a root message in each conference and the Reply feature adds tree-structure discussion threads under the message. If the moderator of the discussion board chooses the moderation option for a conference, users of that conference cannot see the messages posted by other members until the moderator uncheck that option.

4.3 Implementation of Computer-based Delphi Structure

A computer-based Delphi structure was implemented and enforced in Delphi groups. In Sub-section 2.2.2, seven features of Delphi structure was discussed, Table 4.1 compares the implementation of Delphi structure used in this study to the traditional paper-and-pencil Delphi, in terms of those seven features. In paper-and-pencil Delphi, participants' contributions were gathered in anonymous basis. Asynchronous group communication systems provide another option for the mode of contribution– a pen name. In this mode, the identity of the author is revealed by his/her pen-name imprinted on the message he/she has written. Then, the history of a participant's contributions can be traced through his/her pen-name and other participants can evaluate the credibility of the participant based on his/her previous performance in the discussion (not based on his/her real identity) (Turoff, 1972). In this experiment, pen-name is used.

In terms of facilitation, this study uses a combination of human facilitator and GSS features. A human facilitator (the experimenter) posts the scripted instructions in Webboard conference to enforce a step-by-step agenda for Delphi structure, organizes the list of ideas by removing duplications, and makes a report for voting result and posts its URL in Webboard, and implements GSS functions for moderation. To increase external validity of this experiment, restrictive facilitation support is used in this study. For example, the facilitator's role was limited to provide scripted instructions informing what the group has to do next (forward guidance) or providing warning remarks when the group is trying to deviate from the rules (preventive guidance). Following the script, the facilitator implements the GSS feature (a moderated conference) for enforcing nominal idea generation. Since Webboard does not support the functionality with which group members can collaboratively remove duplications after the nominal idea generation phase, the facilitator removed duplicated ideas. Since the experiment played a facilitator role in this experiment, there is a possibility to introduce an experimenter bias in this process. To reduce such bias, the removal of duplications was also done by a strict rule: when there were duplications appearing in a group, only the version which appeared first was left and the subsequent duplications were deleted by the facilitator (with saving the copies of those duplications in a disk). After the idea generation phase, the facilitator copied all the ideas from Webboard, composed a Web-based voting survey form and post its URL in the Voting conference. When the group members fill out the survey, those responses were recorded in an Excel file and the facilitator made a report summarizing the result of the voting. To provide a standard format for the survey and report, Survey Tracker (http://www.surveytracker.com) was used in composing the survey / the report and collecting the responses. Except the organization of the list of ideas with removing duplications, the facilitator did not involve in groups' content process.

For delivery medium, an asynchronous group communication (Webboard) was used, instead of mailed questionnaires. Groups generate ideas, discussed the ideas they generated, and found the URL of the voting survey and the report in conferences in Webboard. A moderated conference was used to enforce the nominal idea generation. When each member posts messages in a moderated conference, he/she only can see the messages posted by him/herself and the messages posted by other members do not appear. After each member generates his/her own ideas alone, the facilitator changed this moderated conference to a regular conference in which all messages appear to every member. Then groups were asked to comment on the ideas generated by others.

Group feedback was given by the facilitator who composed a Web-based voting survey, collected the responses, composed a report, and posted the URL of the report. In this process, the group discussion was controlled; for example, no idea evaluation was allowed while each member fully generates his/her own ideas in a moderated conference. Also following the instruction of the facilitator, groups were asked to comment on others' ideas, not freely discussing the ideas at any time. Also the two rounds of formal voting phases were used to evaluate the ideas. After the first voting, members were given an opportunity to read the voting report, compare their judgments with what the group viewed, then change their original judgments in the second voting. In paper and pencil version, this response-feedback-change process is usually iterated until a certain stopping criterion is met. Due to the time constraints, two rounds of voting were used.

Table 4.1 Paper-and-Pencil Delphi vs. Computerized Delphi Implemented in This Study

	Paper-and-Pencil Delphi	**Delphi structure in this study**
Anonymity	Anonymous contributions	Pen-name is used in this study
Facilitation	**Human Facilitator** designs the procedure and questionnaire / organizes the list of items / summarizes responses and feeds those responses back to the participants.	**Human Facilitator** designs the procedure, posts scripted instructions in Webboard conference, organizes the list of ideas, and makes, posts report of voting result in Webboard, and implements GSS functions. **GSS** implements moderation functions which support Nominal Idea Generation / Group Feedback / Controlled Discussion.
Delivery (Asynchronous Communication Medium)	Facilitator designs and mails questionnaires to participants	Asynchronous group communication system (Webboard) is used for controlled discussion with Delphi structure. Facilitator posts a sequence of instructions in the Webboard conference and also provides the URL for on-line voting surveys.
Nominal Idea Generation	Participants fill out the questionnaire and mail it back to the facilitator.	Participants post ideas in a moderated asynchronous conference.
Group Feedback	Facilitator summarizes and mails participants' responses along with the subsequent questionnaire	Facilitator approves and reveals the list of items generated by group members in the moderated conference. Facilitator generates a report for the voting result and posts the URL of the report in the Webboard.
Controlled Discussion	Participants fill out and mail the questionnaire which asked to comment on other members' ideas or rate them.	Participants comment on others' ideas in a Webboard conference and also provide the reasons / comments in on-line voting surveys.
Iteration	The subsequent questionnaire is distributed to participants along with a summarized report of the previous round. Then, Participants are given opportunities to change their judgments, based on the group view. This response-feedback-change process is iterated until the stopping criteria have been met.	A sequence of instructions is posted in a conference. Two rounds of voting are used.

4.4 Task: the Special Technology Inc. Case

Subjects were asked to complete the Special Technology Inc. Case task (See Appendix G) that was specifically designed for this study. A hypothetical case of a computer chip manufacturing company which had just developed an object tracking device was given to all groups. Groups were required to generate as many ideas of possible applications of such a device as possible, develop positive and negative consequences for each application generated and evaluate each application idea in terms of the level (three point-scale) of potential impacts the consequences of the application may have in U.S. society. This task corresponds to the combination of a creativity task (Type 2) and a decision-making task (Type 4) of McGrath's Task circumplex (McGrath, 1984).

Other examples of creativity tasks used in EBS studies are Tourism task ("How can tourism be improved in Kingston?"), Security task ("How can security on the campus be improved?"), Thumb task ("What would be the advantages and disadvantages if everyone had an extra thumb on each hand?"), and Stakeholder task ("Identify stakeholders to a microcomputer policy decision."). However those tasks have relatively limited number of possible ideas. The Special Technology Inc. task should incorporate much higher diversity of ideas. The use of a task which has a larger number of possible ideas is important in providing a high level of validity on the group size study, since there would be no ceiling effect in larger group. More importantly, it is an example of a complex social policy issue for which more public involvement could be obtained with appropriate structures for large groups of people to participate in what might be termed a "social decision support system" (Turoff et al, 2002). The task was tested and revised based on the subjects' responses to the task questionnaire distributed in the pilot studies.

4.5 Subjects

396 subjects (11 groups per condition) were recruited from undergraduate level courses (CIS350 Computer and Society, CIS455 Management Information Systems, CIS465 Advanced Information Systems) in the Information Systems departments at New Jersey Institute of Technology. Their incentive to participate in the experiment was to obtain 10-20% of the course credits. Since the task required the subjects to come up with new applications of the newly developed tracking device and evaluate those applications, the subjects were recruited from the courses which teach social or organizational issues in information systems. Even though the task did not require any special skills or knowledge in any specific domain, it was decided to limit the subject pool to undergraduates to control the differences in work experiences or in knowledge in pervasive computing.

4.6 Pilot Studies

Two pilot studies were conducted in 2001. Pilot #1 was conducted for three weeks to test the task, the instrument and the procedure. 72 subjects (two groups per condition) were recruited from two undergraduate courses (CIS455 and CIS465). Many problems in the procedure and the task emerged in Pilot #1; especially subjects could not adequately finish the manual ranking procedure and the drop out rate abruptly increased after two weeks. Based on this result, the procedure and the task were modified. Using the modified procedure and task, Pilot #2 was conducted for two and half weeks. A total of 144 subjects recruited from CIS350, CIS455 and CIS465 participated in Pilot #2. Table 4.2 and Table 4.3 summarize the preliminary result of Pilot #2.

Table 4.2 Result of Pilot #2 (Number of raw ideas)

Number of raw ideas: total (per person)

	Small-sized	Medium-sized	Total
Delphi	23, 15,19, 9 (2.75)	28, 37, 31, 16 (2.33)	178 (2.47)
Unstructured	8, 21, 8, 8 (1.875)	16, 15, 16, 9 (1.17)	101 (1.403)
Total	111 (2.3125)	168 (1.75)	

Table 4.3 Result of Pilot #2 (Agreement)

	Small-sized	Medium-sized
Delphi	Group1: no agreement (no discussion after voting) Group2: no agreement (no discussion after voting) Group 3: agreement (3 more votings after initial voting) Group 4: no agreement (discussion after voting)	Group1: agreement (voting using Excel after initial voting, informal leader) Group 2: agreement (voting after initial voting, discussion if ties) Group 3: no agreement (discussion after initial voting) Group 4: no agreement (discussion after initial voting)
Unstructured	Group 1: no agreement (discussion and voting) Group 2: agreement (voting using Excel) Group 3: no agreement (no voting) Group 4: agreement (voting by informal leader)	Group 1: agreement (voting by informal leader) Group 2: agreement (voting by informal leader, leader makes final decision when ties) Group 3: agreement (voting using Excel by informal leader) Group 4: agreement (voting by informal leader, leader makes final decision after seeing other members' responses)

Since it was found that the group in Pilot#2 had a difficulty in coordinating group members' efforts, it was decided to select one member as a "group coordinator" in the main study.

4.7 Research Instruments

In addition to be asked to complete the task, subjects were asked to complete several survey instruments, read the on-line Webboard tutorial and complete three training tasks and each instrument is described below.

Experiment Overview Website: This instrument (See Appendix A) is for the purpose of recruiting the student subjects. This website gives the general requirement, experiment schedule, the link to the Webboard training and the contact information of the experimenter. Subjects were able to download the consent form and background questionnaire from this website. The URL of this website was given to all the potential student subjects by the instructor and students who decided to participate were asked to contact the experimenter through email.

Background Questionnaire: This instrument (See Appendix B) was distributed to subjects before the experiment started to collect demographic information on each subject. To assess the level of their expertise in the task, information regarding the history of full time employment in general and in computer-related industries and the perceived level of expertise / interests subjects have had in pervasive computing was inquired. Since the task requires extensive uses of Webboard, information on the level of Webboard usage was gathered. In addition, the level of experiences in group work and their perceptions about participation in group discussion was asked.

Consent Form: This instrument (See Appendix D) is a standard form used at NJIT by which subjects were informed of the procedure, benefits and risks of participation in the study.

Webboard Tutorial and Training Webboard: A website of the on-line Webboard tutorial was made and subjects were given the URL of this website. This tutorial gives a step-by- step instruction on the basic functions of Webboard needed in completing the task. At the end of this tutorial, subjects were asked to complete the four simple exercises (making an account, posting a message, replying to a message, posting a message in a moderated conference) which were specially made for the training purposes. The purpose of this training is to have subjects obtained basic skills they would need to complete the task using Webboard.

Experiment Webboard: Subjects used this Webboard (See Appendix E for the Delphi groups & Appendix F for the unstructured groups) for the purpose of completing the task. There were six common conferences included in both Delphi and unstructured groups—Read First (which included the overview, the rules, and the grading criteria), Welcome (which was used for self-introduction and selection of group coordinator), Task, Experimenter's Instructions, Group Report (which was used for discussion of group report writing), Questionnaires (where Post-Experiment and Task Questionnaires were posted), and Questions to Experimenter. For the purpose of idea generation and evaluation, a moderated conference, Group List was used only by the Delphi groups, wherein members were not able to read other members' postings for the initial idea generation phase. Voting conference was used only by the Delphi groups, wherein the URL of the voting questionnaires and the voting results were posted. As contrasted, unstructured groups used Discussion conference which was not moderated, for discussion and voting purposes.

Task Survey: The purpose of this instrument (See Appendix H) is to measure subjects' perceptions about the task.

Post-Experiment Questionnaire: The purpose of this instrument (See Appendix I) is to ask the subjects' perceptions to measure the intervening and dependent variables.

Debriefing Webboard: This is a Webboard specifically made for the purpose of educatin g the student subjects about the study. This Webboard gives a detailed explanation of the objectives, literature review, hypotheses, experimental design and procedures. Also in thi s Webboard the experimenter replied to the student subject's questions.

4.8 Detailed Procedures

4.8.1 Recruit

Subjects were recruited from undergraduate courses (CIS350, CIS455 and CIS465) at the New Jersey Institute of Technology. They were given the URL of the experiment overview website to download and fill out the consent form and the background questionnaire.

4.8.2 Training

Recruited subjects were given the URL of the Webboard tutorial and the training Webboard and asked to finish the four training exercises (Making an account, Posting a message, Replying to other person's message, Posting in a message in a moderated conference) in the training Webboard. Each subject was informed that he/she would be receiving a confirmation email after he/she completed all of the four training exercises correctly.

4.8.3 Group Assignment

The subjects who have successfully completed the training exercises were randomly assigned in an experiment group. Six subjects and twelve subjects were randomly assigned into each small-sized and medium-sized group. In order to exclude the effect of anonymity, pen-names are given to the subjects in all conditions. The pen-name consisted of the group ID and the serial number of the member and it was used as the login ID for the experiment Webboard. For example the pen-name "ds101" was given to the first member (01) of the first Delphi small group (ds1). After finishing the training exercises, subjects received an email including a pen-name (the login ID for the experiment Webboard) / the password and the URL of the experiment Webboard on Monday (two days before the experiment starts).

4.8.4 Self-Introduction

During the next two days, each member in a group was asked to log into the experiment Webboard assigned to his/her group using the pen-name and the password given, to introduce himself/herself and to select a group coordinator in the Welcome conference. The purpose of self-introduction was to give each member a sense of existence of other members in his/her group. However, in order to control anonymity, the exposure of members' real names was not allowed in the whole experiment as well as in the self-introduction.

A group coordinator was used in both Delphi and unstructured conditions and he/she was responsible to encourage group members to make sure groups complete all the given sub-tasks and to allocate the work in writing the group report. The purpose of using a group coordinator is to make sure that the groups completed the task and submit the report on time. The use of a group coordinator is advisable in asynchronous environments in which the experimenter has little control over the subjects and especially important for the unstructured groups that have no facilitator supports.

4.8.5 Performing the Task

The actual experiment started on Wednesday (Day 1) and it took 2 1/2 weeks (14 work-days). Different procedures were used in the Delphi groups and unstructured Groups.

4.8.5.1 Delphi Groups.

Day 1: The task (the Special Technology Inc. Case) and the first instruction were posted in the Webboard.

Day 1 – Day 3: *Initial idea generation.* Each member was instructed to post as many ideas about the task as he/she could possibly think of in the Group List conference. Since during this period each member was generating ideas without seeing other members' postings, duplications in ideas were expected. Therefore, at the end of Day 3, duplications of the same ideas were removed by the experimenter (but the copies of the duplicated ideas were saved) from the Group List conference and the messages in the Group List conference were approved and revealed to the members. Then the Group List conference was changed to a regular conference.

Day 4 – Day 6: *Further idea generation and discussion of initial ideas.* Subjects were asked to read the ideas generated in the Group List conference, to add additional ideas, and to post comments on each idea, in terms of description, keywords, positive and negative consequences of each idea. Meanwhile, the initial voting survey using Survey Tracker software was made by the experimenter. At the end of Day 6, the URL of the initial voting survey was posted in the Voting conference.

Day 7 – Day 8: *Initial Voting.* Subjects were asked to read the comments in the Group List conference and to fill out the initial voting survey posted in the Voting conference. In the initial voting survey, subjects were asked to rate each application in terms of five scales of relative importance (Critically Important, Very Important, Important, Slightly Important, Not Important). Meanwhile, the report of the initial voting result and the second voting survey were made by the experimenter. At the end of Day 8, the URLs of the report and the second voting survey were posted in the Voting Result conference.

Day 9 – Day 11: *Discussion on voting results* and *Second Voting.* Subjects were asked to discuss the voting result and to fill out the second voting survey posted in the Voting conference. In the second voting survey, subjects were asked to rate each application in terms of three scales of relative importance (Very Important, Some Important, Not Important). At the end of Day 11, the URL of the report of the second voting result was posted in the Voting conference.

Day 12 – Day 13: *Work on group report.* Groups were asked to read the report of the second voting results, to work on the group report and to upload their group report by Day 13 midnight.

Day 14: *Questionnaires.* Task Questionnaire and Post-Experiment Questionnaire were posted in the Questionnaire conference and the subjects were asked to fill out and emailed those questionnaires.

4.8.5.2 Unstructured Asynchronous Groups.

Day 1: The task (the Special Technology Inc. Case) and the instruction were posted in the Webboard.

Day 1 – Day 13: Groups were asked to discuss the task, generate the list of applications and develop positive and negative consequences of each application. They were also asked to devise their own voting procedure rating the generated applications in terms of three scales of relative importance (Very Important, Some Important, Not Important). Groups were asked to write and upload a group report.

Day 14: *Questionnaires.* Task Questionnaire and Post-Experiment Questionnaire were posted in Questionnaire conference.

4.8.6 Debriefing

After completing Task Questionnaire and Post-Experiment Questionnaire, subjects were given the URL of the Debriefing Webboard.

4.9 Measurement of Variables

4.9.1 Post-Experiment Questionnaire Items

The following dependent variables and the intervening variables were measured by the subjects' responses to the Post-Experiment Questionnaire items. Items on Post-Experiment Questionnaire used five semantic differential scale anchored at five points.

4.9.1.1 Perceived Intellectual Synergy. Seven items were adapted from the Multifactor Leadership Questionnaire (MLQ) (Bass and Avolio, 1996), constructed as Likert-type scales anchored at five points with "Not at all" on the left hand side and "Very much" on the right hand side and included in the Post-Experiment Questionnaire (See Table 4.4).

Table 4.4 Perceived Intellectual Synergy Scale

Item No.	Question / Statement
2	This group process emphasized the value of questioning assumptions.
10	This group process got me to look at problems from many different angles.
13	This group process made me re-examine critical assumptions to question whether they are appropriate.
41	This group process encouraged addressing problems by using reasoning and evidence, rather than unsupported opinion.
27	This group process encouraged me to express my ideas and opinions.
32	This group process encouraged us to rethink ideas which had never been questioned before.
8	This group process sought differing perspectives when solving problems.

4.9.1.2 Perceived Depth of Evaluation. Two items were adapted from Ocker et al. (1995/1996), constructed as Likert-type scales anchored at five points with "Strongly agree" on the left hand side and "Strongly disagree" on the right hand side and included in the Post-Experiment Questionnaire (See Table 4.5).

Table 4.5 Perceived Depth of Evaluation Scale

Item No.	Question / Statement
12	The group process uncovered valid alternatives that I had not considered.
28	The group decision process made me critically reevaluate the validity of the alternatives that I had thought of.

4.9.1.3 Perceived Learning. Six items were adapted from Hiltz (1988), constructed as Likert-type scales anchored at five points with "Strongly agree" on the left hand side and "Strongly disagree" on the right hand side and included in the Post-Experiment Questionnaire (See Table 4.6).

Table 4.6 Perceived Learning Scale

Item No.	Question / Statement
18	After this group process, I developed the ability to communicate clearly about the topic.
11	After this group process, I gained a good understanding of the subject area of object tracking technologies and their applications.
26	After this group process, I learned to identify central issues in the area of object tracking technologies and their applications.
38	After this group process, my skill in critical thinking was increased.
20	After this group process, I learned a great deal of factual information about the subject area of object tracking technologies and their applications.
45	After this group process, I became more interested in the subject area of object tracking technologies and their applications.

4.9.1.4 Perceived Free-riding. Two items were adapted from Dennis et al. (1993), constructed as Likert-type scales anchored at five points and included in the Post-Experiment Questionnaire (See Table 4.7).

Table 4.7 Perceived Free-riding Scale

Item No.	Question / Statement
3	How much do you feel you participated in this task? (A lot / Not much)
16	How satisfied with *your own performance* on this task? (Very satisfied / Very unsatisfied)

4.9.1.5 Evaluation Apprehension. Two items were adapted from Dennis et al. (1993), constructed as Likert-type scales anchored at five points and included in the Post-Experiment Questionnaire (See Table 4.8).

Table 4.8 Evaluation Apprehension Scale

Item No.	Question / Statement
1	Did you feel any apprehension about generating your ideas? (No apprehension / A lot of apprehension)
7	How at ease were you during the idea generation process? (Very at ease / Definitely not at ease)

4.9.1.6 Perceived Equality of Participation. Six items were adapted from Ocker et al., (1995/1996), constructed as Likert-type scale anchored at five points. These five items are included in the Post-Experiment Questionnaire (See Table 4.9).

Table 4.9 Perceived Equality of Participation Scale

Item No.	Question / Statement
5	Only a few members dominated the group discussion. (Strongly agree / Strongly disagree)
40	The work of the group was well divided among members. (Strongly agree / Strongly disagree)
22	One person influenced the group's work more than the rest of the group. (Strongly agree / Strongly disagree)
15	Every member of the group did not have a job to do. (Strongly agree / Strongly disagree)
19	The work of the group was left to those who were considered most capable for the job (Very much / Not at all)
25	The participation in the discussion was: (Evenly distributed / Unevenly distributed)

4.9.1.7 Process Satisfaction. Five-sub items under a question "How would you describe your group's decision process?" were adapted from Ocker et al., (1995/1996), constructed as semantic differential scales anchored at five points and included in the Post-Experiment Questionnaire (See Table 4.10).

Table 4.10 Process Satisfaction Scale

Item No.	Question / Statement
33	Efficient / Inefficient
34	Coordinated / Uncoordinated
35	Fair / Unfair
36	Understandable / Confusing
37	Satisfying / Unsatisfying

4.9.1.8 Outcome Satisfaction. Six items were adapted from Ocker et al., (1995/1996) and Ven de Ven and Delbecq (1974), constructed as Likert-type scales anchored at five points and included in the Post-Experiment Questionnaire (See Table 4.11).

Table 4.11 Outcome Satisfaction Scale

Item No.	Question / Statement
6	How satisfied are you with the *quality* of the ideas your group proposed? (Very satisfied / Very unsatisfied)
43	How satisfied are you with the *quantity* of the ideas your group proposed? (Very satisfied / Very unsatisfied)
14	How confident are you in your group's decisions? (Very confident / Very unconfident)
42	To what extent does your group's work reflect your inputs? (Very great extent / Not at all)
21	To what extent do you feel committed to the group's decisions? (Very great extent / Not at all)
17	To what extent do you feel personally responsible for the quality of the idea your group proposed? (Very great extent / Not at all)

4.9.1.9 Cohesiveness. Five items were adapted from Chidambaram et al. (1990/1991), constructed as a five points-scale (1. Would want very much to stay where I am, 2. Would rather stay where I am than move, 3. Would make no difference to me, 4. Would rather move than stay where I am, 5. Would want very much to move---for item 23), a five point-scales (1. Very much better, 2. Better than most, 3. About the same, 4. Worse than most, 5. Very much worse---for item 29, 30, and 31) and a five-point-scale (1. Really a part of my group, 2. Included in most ways, 3. Included in some ways, but not in others, 4. Don't feel I really belong too much, 5. Don't feel I really belong at all). These five items are included in the Post-Experiment Questionnaire (See Table 4.12).

Table 4.12 Cohesiveness Scale

Item No.	Question / Statement
24	If you had a chance to do the same kind of work in another student work group how would toy feel about moving to another group?
29	The way people get along together
30	The way people work together
31	The way people help each other
39	Do you feel that you are really a part of your student work group?

4.9.2 Participation

The level of participation of each member in performing the task was measured by the word count. For each member, the number of words he/she posted in task-related conferences (Group List and Voting conferences for the Delphi groups and Discussion conference for the unstructured groups) (= *Individual Word Count)* were counted using the software developed by a Ph.D. student at New Jersey Institute of Technology. Among those individual word counts, the word count posted by the group coordinator was recorded for each group (= *Coordinator Word Count)*. Then the total word count posted by all the actual participants and their per person word count was calculated;

Total Word Count = sum (Individual Word Count)

Per Person Word Count = Total Word Count / Number of Actual Participants

4.9.3 Number of Ideas

4.9.3.1 Number of Raw Ideas. The raw ideas were identified by the experimenter from Group List (the Delphi groups) or Discussion (the unstructured groups) conferences in Webboard. Any comment which has the right format (Title, Keywords, and Description) as the task suggested was considered as an idea. A comment which clearly suggested a new idea counted even though it did not conform to the right format. Each identified idea was given a unique serial number xxyyzz-ww-00 (xx; experimental condition, yy; group identification number, zz; member identification number, ww; idea identification number). For the experimental condition, 00, 01, 10, and 11 each represents Delphi small-sized, the Delphi medium-sized, the unstructured small-sized and the unstructured medium-sized group. For example, the idea 010604-16-00 represents the 16th idea in the group and this idea was posted by the 4th member of the 6th Delphi medium-sized group. Then for each group, the number of the identified raw ideas was counted (=Number of Total Raw Ideas).

4.9.3.2 Number of Unique Ideas. To discover unique ideas, the total list of ideas aggregated from all groups (including duplications removed from the list by the facilitator in the Delphi groups) were categorized into eight functions of the devices (Tracking/Monitoring, Logging, Locating, Controlling, Sensing, Recording attendance or inventory, Identifying, and Studying) and subjects to be tracked (such as criminals, animals, etc.). Among the ideas categorized in each category, an idea (i.e. a raw idea) was considered unique if the suggested application added a distinct value to any of the following criteria (1) the device tracks a unique subject, (2) the information collected by the object tracking device is unique and thus a unique (group of) of person(s) can use this information for a distinct purpose, and (3) the implementation of the object tracking device is unique. For example, the ideas "Detecting cheating actions of students using a surveillance camera" and "Detecting cheating actions of students using a tester attached to exam papers" were considered as two different unique ideas even though it tracks the same thing, since the implementations of the technology were different. However, the ideas of "Monitoring Alzheimer patients", "Monitoring memory loss patients" and "Monitoring mentally disturbed patients" were counted as one unique idea, because those subjects to be tracked by the device had exactly the same nature (the patients who have mental disabilities) and purpose (monitoring the location and status of the patients so that they can be easily found when they are lost). 32 ideas that were irrelevant to the task were removed from the analysis.

Table 4.13 shows the number of raw ideas in each category of function. Table 4.14 shows the unique ideas which belonged in the "Controlling" function and each row represents a unique idea.

Table 4.13 Ideas in Each Category (Function)

Category (Function)	Number of Ideas
Tracking / Monitoring	164
Logging	25
Locating	140
Attendance / Inventory	58
Sensing	181
Controlling	31
Identifying	73
Studying	32
Total	704

Table 4.14 Unique Ideas in Controlling Category

Subjects Level 1	Subjects Level 2	Description	Number of Occurrences
Prisoners	In virtual jail	Controlling prisoners at home (Virtual Jail)	1
Prisoners	On house arrest	Controlling prisoners under house arrest	2
Prisoners		Controlling prisoners by paralyzing them by electrical shock	2
Prisoners/Pets		Keeping prisoners/ pets inside	1
Drinkers		Discouraging people from over-drinking	1
Children		Keeping children inside of the designated boundaries by setting an alarm	3
Pets		Keeping pets inside of the designated boundaries by setting an alarm	6
Weapons		Tracking weapons using satellites for disarming	1
Weapons	Bombs	Detonating bombs	1
Weapons	Guns	Controlling unauthorized uses of guns	1
Unauthorized uses of objects		Controlling the unauthorized uses of objects	1
Temperature		Controlling the room temperature in a building	1
Car security		Controlling the security of cars by matching bio-signature of the drivers	1
Violations of restraining orders		Controlling the violation of restraining orders	2

Table 4.14 Unique Ideas in Controlling Category (Continued)

Subjects Level 1	Subjects Level 2	Description	Number of Occurrences
Car security		Controlling the security of cars by matching bio-signature of the drivers	1
Violations of restraining orders		Controlling the violation of restraining orders	2
EZPass		Controlling the EZPass by sending a jamming signal (for the purpose of fraud)	1
Phone network		Controlling the phone network by sending a signal	2
Household objects		Controlling household objects remotely by cell phone	1
Household objects		Controlling household objects by the device implanted in people	2
Personal belongings		Tracking personal belongings by causing them to beep	1

It was observed that ideas with different levels of granularity appeared in one group. Therefore, in determining the unique ideas appearing in a specific group, only the most specific concept was counted as a unique idea in the case of general and specific concepts appearing in one group: for example, only "Tracking suspect's alibi" (specific idea) was counted when the idea of "Tracking suspects" (general idea) also appeared in the same group. This categorization is reasonable since the task asked to generate as many ideas of specific uses of tracking devices for specific subjects, as possible. Table 4.15 shows some examples of the categorization which shows general / specific ideas.

Table 4.15 Example of Categorization for General / Specific Ideas

Function of Device	Subjects	Description	General / Specific
Tracking/Monitoring	People	Tracking/Monitoring people	General
	Suspects	Tracking/Monitoring suspects	More specific
	Suspect's alibi	Tracking suspect's alibi	Most specific
Locating	Cars	Locating cars	General
	Police cars	Locating police cars for quick dispatch	Specific
Attendance	Merchandise	Tracking the inventory of merchandise	General
	Cars in Dealership	Tracking the inventory of a car dealer	Specific

After unique ideas were identified and general / specific relationships among unique ideas were resolved, the number of unique ideas each group produced in the Webboard conference was counted (= Number of Total Unique Ideas in Discussion). Then the group report each group submitted at the end of the experiment was examined. Each idea in the group report was mapped into a unique idea identified in the discussion and counted with the application of the general / specific rule discussed in the above (=Number of Total Unique Ideas in Report).

Table 4.16 is an example of unique ideas appearing in Group #2. The first column represents the idea ID assigned to each raw idea and all of the ideas in Group #2 (a Delphi medium-sized group) have the same Group ID (0101xx-xx-xx). The second column represents the Title of the idea, which was given by the contributor as required in the task. The third column represents the "Unique Ideas" and the ideas specified as "General" were not counted since those ideas were general concepts of other unique ideas appearing in the same group. The last column represents one of the eight categories of the functions. As a result, 19 total unique ideas were counted among 28 total raw ideas in Group 2.

Table 4.16 Example of Unique Ideas in Group #2

Idea ID	Title	Unique Idea	Function
010103-01-00	Pet Tracking System	Locating missing pets	Locating
010103-02-00	Child Tracking System	Locating missing children	Locating
010110-03-00	Military Tracking Device	Locating soldiers in combat for fast rescue or recovery	Locating
010110-04-00	Alternative Surgical Devices	Monitoring the status of internal organs	Sensing
010110-05-00	External Child Safety Device	Locating missing children	Locating
010112-06-00	2K - ID	General	Identifying
010112-07-00	Supply Tracking and Management	General	Attendance
010112-08-00	The Third Eye	General	Tracking
010107-09-00	Fugitive Locator	General	Tracking
010107-10-00	Mini Cam	Monitoring the status of internal organs	Sensing
010109-11-00	Project Prison Watch	Tracking prisoners in a prison	Tracking
010102-12-00	can't hide pill	Tracking suspects	Tracking
010108-13-00	Burglar Detection Device	Detecting house security	Sensing
010101-14-00	ID Reorganization	Identifying an employee for authorizing the access to the restricted area or information	Identifying
010108-15-00	Embryo Defect Device	Recording and transmitting the status of unborn babies	Sensing
010106-16-00	House Arrest Tracking System	Controlling prisoners under house arrest	Controlling
010106-17-00	Asset/Inventory Control System	Tracking inventory of assets which are not for sale	Attendance
010106-18-00	Police Interceptor	Identifying cars manufactured	Identifying
010106-19-00	Luggage Tracking System	Locating luggages for airlines	Locating
010106-20-00	Employee Tracking	Tracking employees' locations	Tracking
010106-21-00	Shipping Solutions Tracking	Locating shipped packages	Locating
010106-22-00	Car Dealership Asset Tracking	Tracking the inventory of a car dealer	Attendance
010102-28-00	Who's missing	General	Tracking

Table 4.16 Example of Unique Ideas in Group #2 (Continued)

Idea ID	Title	Unique Idea	Function
010111-23-00	Pets invisible fence	Keeping pets inside of the designated boundaries by setting an alarm	Controlling
010104-24-00	The ex-convict tracking system	Tracking suspects	Tracking
010110-25-00	Ticket Device	Identifying public transportation users	Identifying
010112-26-00	A tracking device with satellite technology	General	Tracking
010109-27-00	Lethal Device	Locating hazardous objects in an airport	Locating
010102-28-00	Who's missing	General	Tracking

4.9.3.3 Number of Rare Ideas. For each specific unique idea, all the groups which came up with that idea were identified for the purpose of measuring the level of rarity of each idea. For example, "Tracking suspects" was a fairly common idea and 35 out of 44 groups came up with that idea. On the other hand, "Locating organ donors" was a rare idea and it appeared in only one group. For each group, the rare ideas which exclusively appeared in the corresponding group were counted and this measure represents the highest level of rarity (= Number of Total Rare Ideas appearing in One Group). Similarly the rare ideas of which the group shared their ownership with one additional group (i.e., shared by no more than two groups) (=Number of Total Rare Ideas appearing in One or Two Groups) and the ones shared with two additional groups (i.e., shared by no more than three groups) (=Number of Total Rare Ideas appearing in One, Two, or Three Groups) were counted. Each of these three measures for the number of total rare ideas was divided by Number of Actual Participants for the number of per person rare ideas;

Number of Per Person Rare Ideas appearing in One Group = Number of Total Rare Ideas appearing in One Group / Number of Actual Participants

Number of Per Person Rare Ideas appearing in One or Two Groups = Number of Total Rare Ideas appearing in One or Two Groups / Number of Actual Participants

Number of Per Person Rare Ideas appearing in One, Two, or Three Groups = Number of Total Rare Ideas appearing in One, Two, or Three Groups / Number of Actual Participants

4.9.4 Per Person Ideas

In order to calculate the number of per person ideas, the number of total (raw, unique and rare) ideas was divided by the number of actual participants in performing the task. Since different group members disappeared at different points in time during the experiment, the actual participants could only be identified by their intention to stay in their groups throughout the whole process. A member who introduced himself/herself at the beginning and submitted the Post-Experiment or Task Questionnaires at the end was considered to have had intention to stay and thus counted as an actual participant (= Number of Actual Participants). Then the number of total ideas was divided by the number of actual participants to calculate the number of per person ideas;

Number of Per Person Raw Ideas = Number of Total Raw Ideas / Number of Actual Participants

Number of Per Person Unique Ideas in Discussion = Number of Total Unique Ideas in Discussion / Number of Actual Participants

Number of Per Person Unique Ideas in Report = Number of Total Unique Ideas in Report / Number of Actual Participants

Number of Per Person Rare Ideas appearing in One Group = Number of Total Rare Ideas appearing in One Group / Number of Actual Participants

Number of Per Person Rare Ideas appearing in One or Two Groups = Number of Total Rare Ideas appearing in One or Two Groups / Number of Actual Participants

Number of Per Person Rare Ideas appearing in One, Two, or Three Groups = Number of Total Rare Ideas appearing in One, Two, or Three Groups / Number of Actual Participants

4.9.5 Efficiency of Production

The efficiency of production is the measure for the relative productivity of the group in generating unique / rare ideas compared to its general idea generation productivity. The higher value on this measure suggests that the group is more productive in generating unique / rare ideas compared to their general idea generation productivity. In other words, higher values denote that the group produced disproportionately more unique / rare ideas compared to the number of total raw ideas it produced.

Efficiency of Production for Unique Ideas = Number of Total Unique Ideas in Discussion / Number of Total Raw Ideas in Discussion

Efficiency of Production for Rare Ideas appearing in One Group = Number of Total Rare Ideas appearing in One Group / Number of Total Raw Ideas in Discussion

Efficiency of Production for Rare Ideas appearing in One or Two Groups = Number of Total Rare Ideas appearing in One or Two Groups / Number of Total Raw Ideas in Discussion

Efficiency of Production for Rare Ideas appearing in One, Two, or Three Groups = Number of Total Rare Ideas appearing in One, Two, or Three Groups / Number of Total Raw Ideas in Discussion

4.9.6 Inequality of Participation

In addition to the perceived measure (Sub-section 4.8.1.5), the actual inequality participation was measured by the dispersions of word count and raw ideas in each group. The measure was normalized by the total word count to make the groups with different sizes (5-6 vs. 10-12) comparable.

The actual inequality of participation was measured by the dispersion of the word count from its average in a group.

Inequality of participation by Word Count = standard deviation (word count) * SQRT(n-1) / sum (word count), n = Number of Actual Participants

The same calculation was done by using the number of raw ideas generated by each member in the group.

Inequality of participation by Word Count = standard deviation (word count) * SQRT(n-1) / sum (number of raw ideas),   n = Number of Actual Participants

This measure is 0 in the case of perfect equality of participation (when every member contributes the same word count or raw ideas). It converges toward 1 for the large group size (i.e. if the group size is infinite) in the case of the extreme inequality of participation (when one member contributes all the words or raw ideas). In this study, this measure could have 0.89 for the extreme inequality of smallest group size (five members) and 0.96 for the extreme inequality of the largest group size (12 members). It is noted that this measure is slightly favorable to the medium-sized group; in case one member speaks alone, this measure has the value 0.91 for the small-sized group (six members) and the value 0.96 for the medium-sized group (12 members).

4.9.7 Expert Judge Evaluations of Ideas / Group Report

4.9.7.1 Evaluation of Ideas. Five expert judges (three faculty members and two Ph.D. students) evaluated each unique idea in terms of Importance and Creativity. Importance and Creativity of ideas was to be evaluated in terms of the scales as shown in Table 4.17.

In the training session, they were asked to read (1) Instruction (See Appendix K) and (2) Task (See Appendix G). Then they discussed the judging criteria (Importance and Creativity). Each judge was given five sample ideas and asked to judge them without discussing with others. After they discussed the results of these samples, they were asked to fill out the evaluation form (See Appendix K).

Table 4.17 Ideas Evaluation Criteria

Evaluation Criteria	Rating	Meaning
Importance	A	Excellent or Outstanding Importance
	B+	Very Important
	B	Important
	C+	Above Average Importance
	C	Average Importance
	D	Slightly Important
	F	Useless or Not Important
Creativity	A	Exceptionally Creative
	B+	Very Creative
	B	Creative
	C+	Above Average Creative
	C	Average Creativity
	D	Slightly Creative
	F	Not Creative

Importance and Creativity of each idea was calculated by averaging the ratings of the judges. Importance and Creativity of ideas for the group was calculated by averaging the rating of the ideas appearing in the group discussion.

4.9.7.2 Evaluation of Group Report. Four expert judges (Ph.D. students) evaluated the group reports in terms of the two criteria—quality of content and quality of presentation. Content Quality was evaluated by the three sub-criteria, the quality of the ideas, the quality of positive consequences and the quality of negative consequences. Each criterion was evaluated in terms of the seven scales; A: Excellent / Outstanding, B+: Very Good, B: Good, C+: Above Average, C: Average, D: Below Average, F: Very Poor.

In the training session, they were asked to read (1) Instruction (See Appendix L) and (2) Task (See Appendix G). Then they discussed each of the judging criteria. Since the overall quality of the report depended on the multiple sub-criteria, consistency among judges on the weight for each criterion was crucial. After discussion, the judges agreed that the overall quality of group report would be calculated by the following method;

Overall Group Report Quality

= Average (Average (quality of ideas, quality of positive consequences, quality of negative consequences), Presentation Quality)

Then, the judges were given and asked to evaluate five sample group reports without discussion with others. After they discussed the results of these samples, they were given the evaluation form (See Appendix L) and the 44 group reports and asked to return the result in one week. The quality of the group report measure was calculated by averaging the overall quality ratings of the four judges. Table 4.18 summarizes the measurement methods for the intervening and dependent variables.

Table 4.18 Measurement Methods for Intervening and Dependent Variables

<table>
<tr><th>Category</th><th colspan="2">Variables</th><th>Measurement</th></tr>
<tr><td rowspan="8">Process Gain / Loss (Intervening Variables)</td><td colspan="2">Perceived Intellectual Synergy (H1)</td><td>Post-Experiment Questionnaire items</td></tr>
<tr><td colspan="2">Perceived Depth of Evaluation (H2)</td><td>Post-Experiment Questionnaire items</td></tr>
<tr><td colspan="2">Perceived Learning (H3)</td><td>Post-Experiment Questionnaire items</td></tr>
<tr><td colspan="2">Perceived Free-riding (H4)</td><td>Post-Experiment Questionnaire items</td></tr>
<tr><td colspan="2">Evaluation Apprehension (H5)</td><td>Post-Experiment Questionnaire items</td></tr>
<tr><td rowspan="3">Participation</td><td>Total Word Count (H6)</td><td>The total word count by all members</td></tr>
<tr><td>Per Person Word Count (H7)</td><td>Total Word Count / Number of Actual Participants</td></tr>
<tr><td>Coordinator Word Count (H8)</td><td>The word count by the group coordinator</td></tr>
</table>

Table 4.18 Measurement Methods for Intervening and Dependent Variables (Continued)

Category	Variables		Measurement
	Inequality of (H9) Participation	Perceived equality of participation	Post-Experiment Questionnaire items
		Inequality of participation by Word Count	Standard deviation of the word count / Number of Actual Participants
		Inequality of Participation by Number of Raw Ideas	Standard deviation of the number of raw ideas / Number of Actual Participants
Effectiveness (Dependent Variables)	Number of Raw Ideas	Number of Total Raw Ideas (H10)	The total number of ideas including duplications
		Number of Per Person Raw Ideas (H12)	Number of Total Raw Ideas / Number of Actual Participants
	Number of unique ideas	Number of Total Unique Ideas in Discussion (H11)	The number of unique ideas appearing in the Webboard conference
		Number of Total Unique Ideas in Report (H11)	The number of unique ideas appearing in the group report
		Number of Per Person Unique Ideas in Discussion (H13)	Number of Total Unique Ideas in Discussion / Number of Actual Participants
		Number of Per Person Unique Ideas in Report (H13)	Number of Total Unique Ideas in Report / Number of Actual Participants
	Number of Rare Ideas	Number of Total Rare Ideas appearing in One Group (H15)	The number of ideas only appearing in one group
		Number of Total Rare Ideas appearing in One or Two Groups (H15)	The number of ideas appearing in no more than two groups
		Number of Total Rare Ideas appearing in One, Two, or Three Groups (H15)	The number of ideas appearing in no more than three groups
		Number of Per Person Rare Ideas appearing in One Group (H16)	Number of Total Rare Ideas appearing in One Group / Number of Actual Participants
		Number of Per Person Rare Ideas appearing in One or Two Groups (H16)	Number of Total Rare Ideas appearing in One or Two Groups / Number of Actual Participants
		Number of Per Person Rare Ideas appearing in One, Two, or Three Groups (H16)	Number of Total Rare Ideas appearing in One, Two, or Three Groups / Number of Actual Participants

Table 4.18 Measurement Methods for Intervening and Dependent Variables (Continued)

Category	Variables		Measurement
	Importance of Ideas (H14)	Importance of Ideas	Average ratings of the five expert judges (3 faculty members and 2 Ph.D. students)
	Creativity of Ideas (H17)	Creativity of Ideas	Average ratings of the five expert judges (3 faculty members and 2 Ph.D. students)
	Quality of group report (H18)	Content Quality	Average ratings of the expert judges
		Presentation Quality	Average ratings of the expert judges
		Overall Report Quality	Average of Content and Presentation Quality
Satisfaction (Dependent Variables)	Process satisfaction (H19)		Post-Experiment Questionnaire items
	Outcome satisfaction (H20)		Post-Experiment Questionnaire items
	Cohesiveness (H21)		Post-Experiment Questionnaire items
Supplementary Analysis	Efficiency of Idea Production	Efficiency of Unique Idea Production	Number of Total Unique Ideas / Number of Total Raw Ideas
		Efficiency of Rare Idea Production	Number of Total Rare Ideas / Number of Total Raw Ideas

CHAPTER 5

DESCRIPTIVE STATISTICS AND INDEX VALIDATION

Section 5.1 analyzes the demographic information of the subjects and frequency statistics for each demographic characteristic by each condition. The cross tabulation of each demographic characteristic with Chi-square statistics is used to test whether there are significant differences in each demographic characteristic between conditions. Section 5.2 analyzes the subjects' responses to the task questionnaire. Section 5.3 describes the number of ideas in groups and conditions. Section 5.4 describes the procedures to validate the measures and summarizes the validated measures.

5.1 Descriptive Statistics

5.1.1 Demographic Information

Table 5.1 shows the demographic information of the subjects who participated in the experiment. 68 % of the subjects were male and most (72%) of the subjects were between 20 and 25 years old. 90% of the subjects were undergraduate students and 79% of the subjects majored in Computer or Information Sciences. 73% of the subjects have full time work experiences although only 38% of those who were full time employed worked in computer / information / telecommunication related industry. English is the first language for 46% of the subjects and 51% of the subjects were Asian/Pacific Islander. 78% of the subjects had prior experiences in the use of Webboard and 46% of the subjects used Webboard frequently. (See Appendix for the frequency distributions of each characteristic by condition)

Table 5.1 Demographic Information of the Sample

Characteristics		N (%)	Mean (Median)	Std. Dev.
Sex	Female	125 (31.57%)		
	Male	271 (68.43%)		
Age	18-20	73 (20.30%)	23.81 (22.00)	4.78
	21-22	124 (18.67%)		
	23-25	109 (31.71%)		
	26-51	85 (21.74%)		
Years in US	0-4	66 (28.45%)	8.94 (8.00)	6.10
	5-10	77 (33.19%)		
	11-17	63 (27.16%)		
	18-28	26 (11.21%)		
Degree Program	Bachelor's	353 (90.05%)		
	Master's	39 (9.95%)		
Major	IS	165 (42%)		
	CS	117 (30%)		
	Engineering	37 (9%)		
	CIS	27 (7%)		
	Management	27 (7%)		
	Others	21 (5%)		
Months of full-time employment	0	107 (27.44%)	25.67 (9.00)	46.67
	1-12	121 (31.03%)		
	13-24	50 (12.82%)		
	25-60	76 (19.49%)		
	61-348	36 (9.23%)		
Computer-related work experiences	Yes	150 (38.17%)		
	No	243 (61.83%)		
Is English 1st language?	Yes	176 (46.44%)		
	No	203 (53.56%)		
Ethnicity	Asian/Pacific Islander	191 (51%)		
	Caucasian	93 (25%)		
	African-American	46 (12%)		
	Hispanic	27 (7%)		
	Middle Eastern	13 (4%)		
	Others	4 (1%)		
WebBoard usage	Never	79 (22%)		
	1-2 times	67 (18%)		
	3-10 times	49 (14%)		
	Frequently	166 (46%)		

Tables 5.2 – 5.5 are the cross tabulations of the demographic characteristics (sex, degree program, computer-related work experiences, English as the first language) between Delphi and unstructured conditions. Chi-square measures in Table show 5.2 shows the subjects in Delphi and unstructured groups are not significantly different on any of those demographic characteristics.

Chi-square measures in Table show 5.2 shows the subjects in Delphi and unstructured groups are not significantly different in terms of their sexes.

Table 5.2 Differences in Sex by Structure

	Female	Male	Total
Delphi	65 (32.83%)	133 (67.17%)	198 (100%)
Unstructured	60 (30.30%)	138 (69.70%)	198 (100%)

P (λ^2=0.2923, df=1) = 0.5888

Chi-square measures in Table show 5.3 shows the subjects in Delphi and unstructured groups are not significantly different in terms of the degree program they belong to.

Table 5.3 Differences in Degree Program by Structure

	Bachelor's	Master's	Total
Delphi	177 (90.77%)	18 (9,23%)	195 (100%)
Unstructured	176 (89.34%)	21 (10.66%)	197 (100%)

P (λ^2=0.2234, df=1) = 0.6365

Chi-square measures in Table show 5.4 shows the subjects in Delphi and unstructured groups are not significantly different in terms of their computer-related work experiences.

Table 5.4 Differences in Computer-related Work Experiences by Structure

	Yes	No	Total
Delphi	118 (60.20%)	78 (39.50%)	196 (100%)
Unstructured	125 (63.45%)	72 (36.55%)	197 (100%)

P (λ^2=0.4391, df=1) = 0.5076

Chi-square measures in Table show 5.5 shows the subjects in Delphi and unstructured groups are not significantly different in terms of English as the first language.

Table 5.5 Differences in English 1st Language by Structure

	Yes	No	Total
Delphi	108 (56.25%)	84 (43.75%)	192 (100%)
Unstructured	95 (50.80%)	92 (49.20%)	187 (100%)

P (λ^2=1.1304, df=1) = 0.2877

Tables 5.6 – 5.9 are the cross tabulations of the demographic characteristics between the small-sized and the medium-sized conditions. Chi-square measures show the subjects in the small-sized and the medium-sized groups are not significantly different on any of those demographic characteristics. Chi-square measures show the subjects in the small-sized and the medium-sized groups are not significantly different in terms of their sexes.

Table 5.6 Differences in Sex by Group Size

	Female	Male	Total
Small-sized	50 (37.88%)	82 (62.12%)	132 (100%)
Medium-sized	75 (28.41%)	189 (71.59%)	264 (100%)

P (λ^2=3.6531, df=1) = 0.0560

Chi-square measures show the subjects in the small-sized and the medium-sized groups are not significantly different in terms of the degree program they belong to.

Table 5.7 Differences in Degree Program by Group Size

	Bachelor's	Master's	Total
Small-sized	116 (87.88%)	16 (11.12%)	132 (100%)
Medium-sized	237 (91.15%)	23 (8.85%)	260 (100%)

P (λ^2=1.0482, df=1) = 0.3059

Chi-square measures show the subjects in the small-sized and the medium-sized groups are not significantly different in terms of their computer-related work experiences.

Table 5.8 Differences in Computer-related Work Experiences by Group Size

	Yes	No	Total
Small-sized	85 (64.89%)	46 (35.11%)	131 (100%)
Medium-sized	158 (60.31%)	104 (49.69%)	262 (100%)

P (λ^2=0.7763, df=1) = 0.3783

Chi-square measures show the subjects in the small-sized and the medium-sized groups are not significantly different in terms of English as the first language.

Table 5.9 Differences in English 1st Language by Group Size

	Yes	No	Total
Small-sized	68 (59.97%)	58 (56.03%)	126 (100%)
Medium-sized	135 (53.36%)	118 (46.64%)	253 (100%)

P (λ^2=0.0125, df=1) = 0.9109

The above results show that random assignment have scattered sets of subjects in different conditions who are essentially "the same" in terms of their characteristics. (See Appendix C for the frequency tables for Background Questionnaire Items)

5.1.2 Subjects' Perceptions of Task

Ten items in Task Questionnaire asked the subject's perceptions of the task. Tables 5.10 and 5.11 show the differences in the subject's response to Q1 ("How much effort was required to complete this task?") and Chi-Square shows that the responses of the subjects were not significantly different in terms of the structure (p=.8276) or the group size (p=.7845). 84.49% of the subjects responded that they needed to exert above average effort to complete the task.

Table 5.10 Differences in Q1 by Structure
(Q1: How much effort was required to complete this task?)

	very little effort	some effort	average effort	a lot of effort	extraordinary effort	Total
Delphi	8 (4.23%)	20 (10.58%)	53 (28.04%)	50 (26.46%)	58 (30.69%)	189 (100%)
Unstructured	11 (5.95%)	19 (10.27%)	47 (25.41%)	44 (23.78%)	64 (34.59%)	185 (100%)
Total	19 (5.08%)	39 (10.43%)	100 (26.74%)	94 (25.13%)	122 (32.62%)	374 (100%)

P (λ^2=1.49, df=4) = .8276

Table 5.11 Differences in Q1 by Group Size
(Q1: How much effort was required to complete this task?)

	very little effort	some effort	average effort	a lot of effort	extraordinary effort	Total
Small-sized	5 (4.03%)	14 (11.29%)	31 (25.00%)	29 (23.39%)	45 (36.29%)	124 (100%)
Medium-sized	14 (5.60%)	25 (10.00%)	69 (27.60%)	65 (26.00%)	77 (30.80%)	250 (100%)
Total	19 (5.08%)	39 (10.43%)	100 (26.74%)	94 (25.13%)	122 (32.62%)	374 (100%)

P (λ^2=1.73, df=4) = 0.7845

Tables 5.12 and 5.13 show the differences in the subject's response to Q2 ("To what degree do you think the task was interesting and motivating to you?") and Chi-Square shows that the responses of the subjects were not significantly different between the Delphi and the unstructured conditions (p=.8497) or the small-sized and the medium-sized conditions (p=.8019). 21.18% of the subjects responded the task was boring and 37.8% of them said the task was interesting.

Table 5.12 Differences in Q2 by Structure
(Q2: To what degree do you think the task was interesting and motivating to you?)

	extremely boring		neutral		extremely interesting	Total
Delphi	12 (6.38%)	27 (14.36%)	73 (38.83%)	56 (29.79%)	20 (10.64%)	188 (100%)
Unstructured	12 (6.49%)	28 (15.14%)	80 (43.24%)	50 (27.03%)	15 (8.11%)	185 (100%)
Total	24 (6.43%)	55 (14.75%)	153 (41.02%)	106 (28.42%)	35 (9.38%)	373 (100%)

P (λ^2=1.36, df=4) = .8497

Table 5.13 Differences in Q2 by Group Size
(Q2: To what degree do you think the task was interesting and motivating to you?)

	extremely boring		neutral		extremely interesting	Total
Small-sized	7 (5.69%)	22 (17.89%)	49 (39.84%)	33 (26.83%)	12 (9.76%)	123 (100%)
Medium-sized	17 (6.80%)	33 (13.20%)	104 (41.60%)	73 (29.20%)	23 (9.20%)	250 (100%)
Total	24 (6.43%)	55 (14.75%)	153 (41.02%)	106 (28.42%)	35 (9.38%)	373 (100%)

P (λ^2=1.64, df=4) = 0.8019

Tables 5.14 and 5.15 show the differences in the subject's response to Q3 ("How important was it for you to complete this task?") and Chi-Square shows that the responses of the subjects were not significantly different between the Delphi and the unstructured conditions (p=.8128) or the small-sized and the medium-sized conditions (p=.6175). 40.64% of the subjects said the completion of the task had a moderate or higher level of importance to them.

Table 5.14 Differences in Q3 by Structure
(Q3: How important was it for you to complete this task?)

	not important		moderately important		critical	Total
Delphi	53 (28.04%)	60 (31.75%)	36 (19.05%)	25 (13.23%)	15 (7.94%)	189 (100%)
Unstructured	54 (29.19%)	55 (29.73%)	31 (16.76%)	24 (12.97%)	21 (11.35%)	185 (100%)
Total	107 (28.61%)	115 (30.75%)	67 (17.91%)	49 (13.10%)	36 (9.63%)	374 (100%)

P (λ^2=1.58, df=4) = .8128

Table 5.15 Differences in Q3 by Group Size
(Q3: How important was it for you to complete this task?)

	not important		moderately important		critical	Total
Small-sized	40 (32.26%)	34 (27.42%)	19 (15.32%)	18 (14.52%)	13 (10.48%)	124 (100%)
Medium-sized	67 (26.80%)	81 (32.40%)	48 (19.20%)	31 (12.40%)	23 (9.20%)	250 (100%)
Total	107 (28.61%)	115 (30.75%)	67 (17.91%)	49 (13.10%)	36 (9.63%)	374 (100%)

P (λ^2=2.65, df=4) = 0.6175

Tables 5.16 and 5.17 show the differences in the subject's response to Q4 ("How easy or difficult did you find this task as an individual?") and Chi-square shows that the responses of the subjects were not significantly different between the Delphi and the unstructured conditions (p=.5360) or the small-sized and the medium-sized conditions (p=.7275). 35.56% and 36.90% of the subjects found the task easy and difficult respectively.

Table 5.16 Differences in Q4 by Structure
(Q4: How easy or difficult did you find this task as an individual?)

	extremely easy		**neutral**		**extremely difficult**	**Total**
Delphi	21 (11.11%)	41 (21.69%)	51 (26.98%)	43 (22.75%)	33 (17.46%)	189 (100%)
Unstructured	27 (14.59%)	44 (23.78%)	52 (28.11%)	40 (21.62%)	22 (11.89%)	185 (100%)
Total	48 (12.83%)	85 (22.73%)	103 (27.54%)	83 (22.19%)	55 (14.71%)	374 (100%)

P (λ^2=3.13, df=4) = .5360

Table 5.17 Differences in Q4 by Group Size
(Q4: How easy or difficult did you find this task as an individual?)

	extremely easy		**neutral**		**extremely difficult**	**Total**
Small-sized	13 (4.13%)	32 (11.57%)	32 (29.75%)	27 (31.40%)	20 (23.14%)	124 (100%)
Medium-sized	35 (5.13%)	53 (8.55%)	71 (25.64%)	56 (27.35%)	35 (33.33%)	250 (100%)
Total	48 (12.83%)	85 (22.73%)	103 (27.54%)	83 (22.19%)	55 (14.71%)	374 (100%)

P (λ^2=2.04, df=4) = .7275

Tables 5.18 and 5.19 show the differences in the subject's response to Q5 ("How enjoyable did you find to work on this task using the procedures and system provided?") and Chi-Square shows that the responses of the subjects were not significantly different between the Delphi and the unstructured conditions (p=.7478) or the small-sized and the medium-sized conditions (p=.5906). 68.45% of the subjects found the task neutral or enjoyable and 31.55% thought the task was unpleasant.

Table 5.18 Differences in Q5 by Structure
(Q5: How enjoyable did you find to work on this task using the procedures and system provided?)

	extremely unpleasant		**neutral**		**extremely enjoyable**	**Total**
Delphi	15 (7.94%)	40 (21.16%)	56 (29.63%)	44 (23.28%)	34 (17.99%)	189 (100%)
Unstructured	20 (10.81%)	43 (23.24%)	50 (27.03%)	45 (24.32%)	27 (14.59%)	185 (100%)
Total	35 (9.36%)	83 (22.19%)	106 (28.34%)	89 (23.80%)	61 (16.31%)	374 (100%)

P (λ^2=1.93, df=4) = .7478

Table 5.19 Differences in Q5 by Group Size
(Q5: How enjoyable did you find to work on this task using the procedures and system provided?)

	extremely unpleasant		**neutral**		**extremely enjoyable**	**Total**
Small-sized	5 (4.13%)	14 (11.57%)	36 (29.75%)	38 (31.40%)	28 (23.14%)	121 (100%)
Medium-sized	6 (5.13%)	10 (8.55%)	30 (25.64%)	32 (27.35%)	39 (33.33%)	117 (100%)
Total	35 (9.36%)	83 (22.19%)	106 (28.34%)	89 (23.80%)	61 (16.31%)	374 (100%)

P (λ^2=2.81, df=4) = .5906

Tables 5.20 and 5.21 show the differences in the subject's response to Q6 ("Did the task description provide you with enough information to easily carry out the task?") and Chi-Square shows that the responses of the subjects were significantly different between the Delphi and the unstructured conditions (p=.0288). Compared to the subjects in the unstructured condition (13.79%), relatively more of the subjects in the Delphi conditions (16.53%) felt the task was ambiguous and did not provide enough information to carry out the task. Similarly, relatively more of the subjects in the unstructured condition (62.93%) thought the task was unambiguous and did provide enough information than the subjects in The Delphi condition (58.93%).

From this result, it was inferred that the Delphi groups had more difficulty to comprehend the task even though the groups in both conditions were given exactly the same task. Due to the nature of the Delphi structure, the Delphi groups completed the task in a more self-reflective manner compared to the unstructured groups who were more inter-responsive with more interactions among group members. Therefore, the unstructured groups might have had more opportunities to help each other in comprehending the task and building up the common understanding on the task. But there was no significant differences between the small-sized and the medium- sized conditions (p=.8174).

Table 5.20 Differences in Q6 by Structure
(Q6: Did the task description provide you with enough information to easily carry out the task?)

	definitely		somewhat		not at all	Total
Delphi	58 (35.54%)	48 (23.14%)	47 (24.79%)	26 (13.22%)	10 (3.31%)	121 (100%)
Unstructured	52 (31.03%)	73 (31.90%)	35 (23.28%)	14 (7.76%)	9 (6.03%)	183 (100%)
Total	110 (19.57%)	121 (32.53%)	82 (22.04%)	40 (10.75%)	19 (5.11%)	372 (100%)

P (λ^2=10.81*, df=4) = .0288

Table 5.21 Differences in Q6 by Group Size
(Q6: Did the task description provide you with enough information to easily carry out the task?)

	definitely		somewhat		not at all	Total
Small-sized	36 (2.27%)	44 (35.77%)	27 (21.95%)	11 (8.94%)	5 (4.07%)	123 (100%)
Medium-sized	74 (29.72%)	77 (30.92%)	55 (22.09%)	29 (11.65%)	14 (5.62%)	249 (100%)
Total	110 (19.57%)	121 (32.53%)	82 (22.04%)	40 (10.75%)	19 (5.11%)	372 (100%)

P (λ^2=1.55, df=4) = .8174

Tables 5.22 and 5.23 show the differences in the subject's response to Q7 ("Did the task description make it clear what was to be accomplished?") and Chi-Square shows that the responses of the subjects were not significantly different between the Delphi and the unstructured conditions (p=.3064) or the small-sized and the medium-sized conditions (p=.2307). The task description was relatively clear to the most of the subjects (85.29%).

Table 5.22 Differences in Q7 by Structure
(Q7: Did the task description make it clear what was to be accomplished?)

	unclear		fairly clear		very clear	Total
Delphi	4 (2.12%)	26 (13.76%)	51 (26.98%)	48 (25.40%)	60 (31.75%)	189 (100%)
Unstructured	8 (4.32%)	17 (9.19%)	45 (24.32%)	59 (31.89%)	56 (30.27%)	185 (100%)
Total	12 (3.21%)	43 (11.50%)	96 (25.67%)	107 (28.61%)	116 (31.02%)	374 (100%)

P (λ^2=4.82, df=4) = .3064

Table 5.23 Differences in Q7 by Group Size
(Q7: Did the task description make it clear what was to be accomplished?)

	unclear		fairly clear		very clear	Total
Small-sized	6 (4.84%)	9 (7.26%)	36 (29.03%)	33 (26.61%)	40 (32.26%)	124 (100%)
Medium-sized	6 (2.40%)	34 (13.60%)	60 (24.00%)	74 (29.60%)	76 (30.40%)	250 (100%)
Total	12 (3.21%)	43 (11.50%)	96 (25.67%)	107 (28.61%)	116 (31.02%)	374 (100%)

P (λ^2=5.60, df=4) = .2307

Tables 5.24 and 5.25 show the differences in the subject's response to Q7 ("Was there a clearly defined body of knowledge that could guide you in doing this work?") and Chi-Square shows that the responses of the subjects were not significantly different between the Delphi and the unstructured conditions (p=.5399) or the small-sized and the medium-sized conditions (p=.5302). More subjects (40.65%) felt that the task did not provide a clearly defined body of knowledge that could guide them in doing their work and only 18.19% thought the task did provide a clearly defined body of knowledge.

Table 5.24 Differences in Q8 by Structure
(Q8: Was there a clearly defined body of knowledge that could guide you in doing this work?)

	definitely		somewhat		not at all	Total
Delphi	14 (7.41%)	19 (10.05%)	84 (44.44%)	58 (30.69%)	14 (7.41%)	189 (100%)
Unstructured	14 (7.57%)	21 (11.35%)	70 (37.84%)	58 (31.35%)	22 (11.89%)	185 (100%)
Total	28 (7.49%)	40 (10.70%)	154 (41.18%)	116 (31.02%)	36 (9.63%)	374 (100%)

P (λ^2=3.11, df=4) = .5399

Table 5.25 Differences in Q8 by Group Size
(Q8: Was there a clearly defined body of knowledge that could guide you in doing this work?)

	definitely		somewhat		not at all	Total
Small-sized	13 (10.48%)	15 (12.10%)	47 (37.90%)	38 (30.65%)	11 (8.87%)	124 (100%)
Medium-sized	15 (6.00%)	25 (10.00%)	107 (42.80%)	78 (31.20%)	25 (10.00%)	250 (100%)
Total	28 (7.49%)	40 (10.70%)	154 (41.18%)	116 (31.02%)	36 (9.63%)	374 (100%)

P (λ^2=3.17, df=4) = .5302

Tables 5.26 and 5.27 show the differences in the subject's response to Q9 ("Was there an understandable approach that could be followed in doing your contributions to the task?"). Chi-Square shows that the responses of the subjects were not significantly different between the Delphi and the unstructured conditions (p=.0630) or between the small-sized and the medium-sized conditions (p=.3298). 32.98% of the subjects in the unstructured groups felt that there was an understandable approach that could be followed in the task, while this percentage is 28.04% for the subjects in the Delphi groups. 35.45% (the Delphi groups) and 24.86% (the unstructured groups) of the subjects were neutral and 36.51% (the Delphi groups) and 42.16% (the unstructured groups) of the subjects responded negatively to this question.

Table 5.26 Differences in Q9 by Structure
(Q9: Was there an understandable approach that could be followed in doing your contributions to the task?)

	definitely		somewhat		not at all	Total
Delphi	19 (10.05%)	34 (17.99%)	67 (35.45%)	48 (25.40%)	21 (11.11%)	189 (100%)
Unstructured	12 (6.49%)	49 (26.49%)	46 (24.86%)	57 (30.81%)	21 (11.35%)	185 (100%)
Total	31 (8.29%)	83 (22.19%)	113 (30.21%)	105 (28.07%)	42 (11.23%)	374 (100%)

P (λ^2=8.92, df=4) = .0630

Table 5.27 Differences in Q9 by Group Size
(Q9: Was there an understandable approach that could be followed in doing your contributions to the task?)

	definitely		somewhat		not at all	Total
Small-sized	14 (11.29%)	31 (25.00%)	31 (25.00%)	33 (26.61%)	15 (12.10%)	124 (100%)
Medium-sized	17 (6.80%)	52 (20.80%)	82 (32.80%)	72 (28.80%)	27 (10.80%)	250 (100%)
Total	31 (8.29%)	83 (22.19%)	113 (30.21%)	105 (28.07%)	42 (11.23%)	374 (100%)

P (λ^2=4.61, df=4) = .3298

Tables 5.28 and 5.29 show the differences in the subject's response to Q7 ("Was there a clearly defined body of knowledge that could guide you in doing this work?") and Chi-Square shows that the responses of the subjects were not significantly different between the Delphi and the unstructured conditions (p=.8007) or the small-sized and the medium-sized conditions (p=.6114). More subjects (40.65%) felt that the task did not provide a clearly defined body of knowledge that could guide them in doing their work and only 18.19% thought the task did provide a clearly defined body of knowledge.

Table 5.28 Differences in Q10 by Structure
(Q10: 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	Total
Delphi	10 (5.29%)	25 (13.23%)	61 (32.28%)	62 (32.80%)	31 (16.40%)	189 (100%)
Unstructured	15 (8.11%)	19 (14.59%)	30 (28.65%)	40 (32.43%)	22 (16.22%)	117 (100%)
Total	25 (6.68%)	52 (13.90%)	114 (30.48%)	122 (32.62%)	61 (16.31%)	374 (100%)

P (λ^2=1.64, df=4) = .8007

Table 5.29 Differences in Q10 by Group Size
(Q10: 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	Total
Small-sized	11 (8.87%)	20 (16.13%)	35 (28.23%)	40 (32.26%)	18 (1452%)	124 (100%)
Medium-sized	14 (5.60%)	32 (12.80%)	79 (31.60%)	82 (32.80%)	43 (17.20%)	250 (100%)
Total	25 (6.68%)	52 (13.90%)	114 (30.48%)	122 (32.62%)	61 (16.31%)	374 (100%)

P (λ^2=2.67, df=4) = .6144

5.1.3 Number of Ideas

5.1.3.1 Number of Total Raw Ideas. After 32 irrelevant ideas were removed, 704 total raw ideas (including duplications) were collected from all the groups. Table 5.30 represents the number of total raw ideas produced by the eleven groups in each condition. The Delphi medium-sized groups produced the total raw ideas (247) most. The eleven groups in the unstructured medium-sized, the Delphi small-sized and the unstructured small-sized conditions produced 192, 157 and 108 total raw ideas respectively.

Table 5.30 Number of Total Raw Ideas per Condition

Total: 704
Mean: 16.00
Std.: 6.50

	SMALL-SIZED			MEDIUM-SIZED		
DELPHI	Group 1	13	Delphi Small-sized Total: 157 Mean: 14.27 Std.: 1.95	Group 1	28	Delphi Medium-sized Total: 247 Mean: 22.45 Std.: 6.31
	Group 2	14		Group 2	14	
	Group 3	13		Group 3	18	
	Group 4	15		Group 4	22	
	Group 5	14		Group 5	11	
	Group 6	12		Group 6	28	
	Group 7	16		Group 7	26	
	Group 8	13		Group 8	20	
	Group 9	13		Group 9	24	
	Group 10	15		Group 10	32	
	Group 11	19		Group 11	24	
UNSTRUCTURED	Group 1	8	Unstructured Small-sized Total: 108 Mean: 9.82 Std.: 4.45	Group 1	14	Unstructured Medium-sized Total: 192 Mean: 17.45 Std.: 4.92
	Group 2	22		Group 2	12	
	Group 3	7		Group 3	17	
	Group 4	10		Group 4	13	
	Group 5	5		Group 5	18	
	Group 6	11		Group 6	19	
	Group 7	7		Group 7	23	
	Group 8	8		Group 8	16	
	Group 9	9		Group 9	28	
	Group 10	11		Group 10	12	
	Group 11	10		Group 11	20	

5.1.3.2 Number of Total Unique Ideas. Using the method described in sub-section 4.9.3.2, unique ideas were identified from the above 704 total raw ideas. The unique ideas were counted in each group first. Then the unique ideas from all the 11 groups in each condition (the Delphi small-sized, the Delphi medium-sized, the unstructured small-sized and the unstructured medium-sized) were pooled and the total unique ideas were identified among those pooled ideas. This identification result in 67 total unique ideas from the Delphi small-sized groups, 111 from the Delphi medium-sized groups, 52 from the unstructured small-sized groups, and 86 groups from the unstructured medium-sized groups. Table 5.31 shows the result of this analysis.

Among the 139 pooled unique ideas generated by all of the Delphi small-sized groups, 72 ideas (52%) were identified duplications. The same was for 100 (47%) duplications out of 211 pooled unique ideas from the Delphi medium-sized groups, 37 (42 %) duplications out of 89 pooled unique ideas from the unstructured small-sized groups and 85 (50%) duplications out of 171 pooled unique ideas from unstructured medium groups. With the use of the same pooling method, 132 total unique ideas were identified from the Delphi (the Delphi small-sized and the Delphi medium-sized) groups, 110 from the unstructured (the unstructured small-sized and the unstructured medium-sized) groups, 94 from the small-sized (the Delphi small-sized and the unstructured small-sized) groups and 145 from the medium-sized (the Delphi medium-sized and the unstructured medium-sized) groups. In this process, 46 (26%) duplications out of 178, 28 (20%) duplications out of 138, 25 (21%) duplications out of 119, and 52 (26%) duplications out of 197 unique ideas were removed from the Delphi, the unstructured, the small-sized, and the medium-sized groups. Similarly, ideas from all of the groups in the four conditions were pooled and from these 704 ideas, 188 ideas were identified as unique. 73% (516) duplications were eliminated in this process.

Table 5.31 Number of Total Unique Ideas in Discussion per Condition

	SMALL-SIZED			MEDIUM-SIZED			
DELPHI	Group 1	12	Delphi Small-sized Pooled total: 139 Unique: 67	Group 1	19	Delphi Medium-sized Pooled Total: 211 Unique : 111	Delphi Pooled Total: 178 Unique: 132
	Group 2	13		Group 2	19		
	Group 3	10		Group 3	10		
	Group 4	14		Group 4	19		
	Group 5	13		Group 5	8		
	Group 6	10		Group 6	27		
	Group 7	12		Group 7	25		
	Group 8	12		Group 8	19		
	Group 9	12		Group 9	21		
	Group 10	14		Group 10	26		
	Group 11	17		Group 11	18		
UNSTRUCTURED	Group 1	7	Unstructured Small-sized Pooled Total: 89 Unique: 52	Group 1	12	Unstructured Medium-sized Pooled Total: 171 Unique: 86	Unstructured Pooled Total: 138 Unique: 110
	Group 2	12		Group 2	12		
	Group 3	5		Group 3	16		
	Group 4	9		Group 4	9		
	Group 5	5		Group 5	17		
	Group 6	11		Group 6	13		
	Group 7	7		Group 7	21		
	Group 8	6		Group 8	15		
	Group 9	8		Group 9	25		
	Group 10	9		Group 10	12		
	Group 11	10		Group 11	19		
	Small-sized Pooled Total: 119 Unique: 94			Medium-sized Pooled Total: 197 Unique: 145			Pooled Total: 704 Unique: 188

Table 5.32 shows the ratio of unique ideas and duplications in each condition.

Table 5.32 Duplication Ratios

	Small-sized			Medium-sized			Total		
Delphi	**Sum**	**Unique**	**Dup**	**Sum**	**Unique**	**Dup**	**Sum**	Unique	Dup
	139 (100%)	67 (52%)	72 (48%)	211 (100%)	111 (47%)	100 (53%)	178 (100%)	132 (26%)	46 (74%)
Unstructured	Sum	Unique	Dup	Sum	Unique	Dup	Sum	Unique	Dup
	89 (100%)	52 (42%)	37 (58%)	171 (100%)	86 (50%)	85 (50%)	138 (100%)	110 (20%)	28 (80%)
Total	Sum	Unique	Dup	Sum	Unique	Dup	Sum	Unique	Dup
	119 (100%)	94 (21%)	25 (79%)	197 (100%)	145 (26%)	52 (74%)	704 (100%)	188 (73%)	516 (27%)

5.1.3.3 Number of Total Rare Ideas. Table 5.33 shows the result of the identification of the rare ideas by the use of the method described in Sub-section 4.9.1. Among the ideas generated by each group, the rare ideas were identified with the different levels of rarity. The column G1 represents the number of ideas only the group itself came up with. The column G2 represents the number of ideas two groups (including additional one group as well as the group itself) came up with. Since the same idea was contributed by two groups, one group's contribution for one idea was counted as 1/2=0.5. The similar logic applies to the column G3, which represents the number of ideas three groups (including additional one group as well as the group itself) came up with. Since the same idea was contributed by three groups, one group's contribution for one idea was counted as 1/3=0.33. The column G(1+2) represent the contribution of one group for generating the rare ideas which no more than two groups (including the group itself) came up with. This number is calculated by G1+G2. Similarly, the number of rare ideas which no more than three groups came up with, G(1+2+3), was calculated by G1+G2+G3.

Table 5.33 Number of Total Rare Ideas per Condition

		SMALL-SIZED					MEDIUM-SIZED				
		G1	G2	G3	G(1+2)	G(1+2+3)	G	G2	G3	G(1+2)	G(1+2+3)
DELPHI	Group 1	3	1	0.33	4.00	4.33	2	0.5	1.33	2.50	3.83
	Group 2	0	1.5	0.00	1.50	1.50	3	0.5	0.00	3.50	3.50
	Group 3	3	0.5	0.00	3.50	3.50	1	0.5	0.67	1.50	2.17
	Group 4	3	0.5	0.00	3.50	3.50	2	1.5	0.33	3.50	3.83
	Group 5	4	0.5	0.00	4.50	4.50	1	0	0.00	1.00	1.00
	Group 6	1	0	1.00	1.00	2.00	8	1.5	0.33	9.50	9.83
	Group 7	1	1	0.00	2.00	2.00	6	1.5	0.67	7.50	8.17
	Group 8	0	1.5	0.00	1.50	1.50	3	1.5	1.67	4.50	6.17
	Group 9	3	1	0.33	4.00	4.33	4	0.5	0.33	4.50	4.83
	Group 10	4	0.5	0.67	4.50	5.17	5	2.5	0.67	7.50	8.17
	Group 11	6	1	0.67	7.00	7.67	4	1	0.00	5.00	5.00
UNSTRUCTURED	Group 1	2	0	0.00	2.00	2.00	1	0.5	0.67	1.50	2.17
	Group 2	2	0.5	0.00	2.50	2.50	2	0	0.00	2.00	2.00
	Group 3	0	0	0.00	0	0.00	3	0.5	0.67	3.50	4.17
	Group 4	1	0.5	0.00	1.50	1.50	4	0	0.00	4.00	4.00
	Group 5	1	0	0.00	1.00	1.00	5	0	0.33	5.00	5.33
	Group 6	1	0.5	0.67	1.50	2.17	3	1	0.00	4.00	4.00
	Group 7	1	0.5	0.33	1.50	1.83	3	1	0.33	4.00	4.33
	Group 8	0	0.5	0.00	0.50	0.50	4	0.5	0.33	4.50	4.83
	Group 9	1	1	0.00	2.50	2.00	4	1.5	0.00	5.50	5.50
	Group 10	2	0.5	0.00	2.50	2.50	5	1	0.67	6.00	6.67
	Group 11	0	2.5	0.00	2.50	2.50	4	1	0.00	5.00	5.50

Table 5.34 represents the number of total rare ideas appearing in one group in each group and condition. These numbers correspond to the column G3 of Table 5.33.

Table 5.34 Number of Total Rare Ideas Appearing in One Group

	SMALL-SIZED			MEDIUM-SIZED			
DELPHI	Group 1	3	Delphi Small : 28	Group 1	2	Delphi Medium : 39	Delphi: 67
	Group 2	0		Group 2	3		
	Group 3	3		Group 3	1		
	Group 4	3		Group 4	2		
	Group 5	4		Group 5	1		
	Group 6	1		Group 6	8		
	Group 7	1		Group 7	6		
	Group 8	0		Group 8	3		
	Group 9	3		Group 9	4		
	Group 10	4		Group 10	5		
	Group 11	6		Group 11	4		
UNSTRUCTURED	Group 1	2	Unstructured Small : 11	Group 1	1	Unstructured Medium : 38	Unstructured: 49
	Group 2	2		Group 2	2		
	Group 3	0		Group 3	3		
	Group 4	1		Group 4	4		
	Group 5	1		Group 5	5		
	Group 6	1		Group 6	3		
	Group 7	1		Group 7	3		
	Group 8	0		Group 8	4		
	Group 9	1		Group 9	4		
	Group 10	2		Group 10	5		
	Group 11	0		Group 11	4		
	Small: 39			Medium: 77			Total Rare (One Group) Ideas: 116

Table 5.35 represents the number of total rare ideas appearing in one or two groups in each group and condition. These numbers correspond to the column G(1+2) of Table 5.33.

Table 5.35 Number of Total Rare Ideas Appearing in One or Two Groups

	SMALL-SIZED			MEDIUM-SIZED			
DELPHI	Group 1	4.00	Delphi Small : 37	Group 1	2.50	Delphi Medium : 50.5	Delphi: 87.5
	Group 2	1.50		Group 2	3.50		
	Group 3	3.50		Group 3	1.50		
	Group 4	3.50		Group 4	3.50		
	Group 5	4.50		Group 5	1.00		
	Group 6	1.00		Group 6	9.50		
	Group 7	2.00		Group 7	7.50		
	Group 8	1.50		Group 8	4.50		
	Group 9	4.00		Group 9	4.50		
	Group 10	4.50		Group 10	7.50		
	Group 11	7.00		Group 11	5.00		
UNSTRUCTURED	Group 1	2.00	Unstructured Small : 17.5	Group 1	1.50	Unstructured Medium : 45	Unstructured: 62.5
	Group 2	2.50		Group 2	2.00		
	Group 3	0		Group 3	3.50		
	Group 4	1.50		Group 4	4.00		
	Group 5	1.00		Group 5	5.00		
	Group 6	1.50		Group 6	4.00		
	Group 7	1.50		Group 7	4.00		
	Group 8	0.50		Group 8	4.50		
	Group 9	2.50		Group 9	5.50		
	Group 10	2.50		Group 10	6.00		
	Group 11	2.50		Group 11	5.00		
	Small: 54.5			Medium: 95.5			Total Rare (One or Two Groups) Ideas: 150

Table 5.36 represents the number of total rare ideas appearing in one, two, or three groups in each group and condition. These numbers correspond to the column G(1+2+3) of Table 5.33.

Table 5.36 Number of Rare Ideas Appearing in One, Two, or Three Groups

	SMALL-SIZED			MEDIUM-SIZED			
	Group 1	4.33	Delphi Small : 40	Group 1	3.83	Delphi Medium : 56.5	Delphi: 96.5
	Group 2	1.50		Group 2	3.50		
	Group 3	3.50		Group 3	2.17		
	Group 4	3.50		Group 4	3.83		
	Group 5	4.50		Group 5	1.00		
	Group 6	2.00		Group 6	9.83		
	Group 7	2.00		Group 7	8.17		
	Group 8	1.50		Group 8	6.17		
	Group 9	4.33		Group 9	4.83		
	Group 10	5.17		Group 10	8.17		
	Group 11	7.67		Group 11	5.00		
UNSTRUCTURED	Group 1	2.00	Unstructured Small : 18.5	Group 1	2.17	Unstructured Medium : 48	Unstructured: 66.5
	Group 2	2.50		Group 2	2.00		
	Group 3	0.00		Group 3	4.17		
	Group 4	1.50		Group 4	4.00		
	Group 5	1.00		Group 5	5.33		
	Group 6	2.17		Group 6	4.00		
	Group 7	1.83		Group 7	4.33		
	Group 8	0.50		Group 8	4.83		
	Group 9	2.00		Group 9	5.50		
	Group 10	2.50		Group 10	6.67		
	Group 11	2.50		Group 11	5.50		
	Small: 58.5			Medium: 104.5			Total Rare (One, Two, or Three Groups) Ideas: 163

Table 5.37 summarizes the ideas in each condition. For the total number of unique ideas in discussion, for example, the column "Delphi" (132 Total unique ideas) is the total unique ideas collected from all the Delphi small (67 total unique ideas) and Delphi medium (111 total unique ideas) groups after removing 46 (=67+111-132) duplications. The unique ideas in discussion (188) were counted from the total raw ideas in all groups (704) with removal of 516 (=704-188) duplications.

Table 5.37 Number of Ideas in Each Condition (Summary)

	DS	DM	US	UM	D	U	S	M	Total
Total Raw Ideas	157	247	108	192	404	300	265	439	704
Total Unique Ideas	67	111	52	86					316
					132	110			242
							94	145	239
									188
Total Rare Ideas (One Group)	28	39	11	38	67	49	39	77	116
Total Rare Ideas (One, or Two Groups)	37	50.5	17.5	45	87.5	62.5	54.5	95.5	150
Total Rare Ideas (One, Two, or Three Groups)	40	56.5	18.5	48	96.5	66.5	58.5	104.5	163

5.2 Index Validation

5.2.1 Post-Experiment Questionnaire Scale Validation

In order to assess the construct validity of the Post-Experiment Questionnaire items, factor analysis was done. Table 5.54 is the matrix of factor loading after a rotation (PROMAX) in the initial phase in which all the items were included. PROMAX is an oblique rotation method which can be used when there is no absolute theoretical foundation that there is no correlation among the constructs. Since the constructs being tested in this study are expected to be related since they have the common factor of measuring the perceptions to the group process or outcomes. Initially 9 factors (the factors which have eigenvalue greater than 1) were extracted. Items which were not loaded into any factor (Q4, Q9, In order to reduce the number of items and to improve the interpretability of the factors extracted, the items which was not loaded to any factor or the items with relatively low regression coefficient were eliminated in the further analysis.

Table 5.38 Initial Factor Loadings of Post-Experiment Questionnaire Items

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
Q2		.82								
Q10		.64								
Q13		.80								
Q41		.49								.46
Q27		.40								
Q32		.61								
Q8		.36							.52	
Q24R									.65	
Q18R			.42							
Q11R			.86							
Q26R			.68							
Q38R										
Q20R			.74							
Q45R			.63							
Q12R			.61					.39		
Q28R		.37	.36							
Q5						.65				
Q40R	.62									
Q22						.80				
Q15						.44				
Q19						.63				
Q25R						.43				
Q3				-.83						
Q16				.78						
Q1							.80			
Q7							.75			
Q33R	.61									
Q34R	.87									
Q35R	.85									
Q36R	.83									
Q37R	.67									
Q6R										
Q14R								.64		
Q17R				.69						
Q21R				.41						
Q42R				.51						
Q43R								.56		
Q24R										
Q29R					.86					
Q30R					.79					
Q31R					.72					
Q39R				.54						

Among the factors with no ladings, Q4, Q9, Q44 without prior attempts for validity tests were removed first. Then Q3, Q12, Q16, Q17, Q23, Q24, Q28, Q39, Q40, Q42 were eliminated to reduce the number of factors and to increase the interpretability of the constructs. Table 5.39 shows the result of the factor loadings for the finalized items which would be included in the further analysis. Table 5.40 shows the variance explained by these factors.

Table 5.39 Factor Loadings of Items Finalized

	F1 (Process Satisfaction)	F2 (Learning)	F3 (Intellectual Synergy)	F4 (Cohesiveness)	F5 (Perceived equality of Participation	F6 (Outcome Satisfaction)	F7 (Evaluation Apprehension)
Q33R	.59						
Q34R	.84						
Q35R	.86						
Q36R	.83						
Q37R	.68						
Q18R		.60					
Q11R		.79					
Q26R		.73					
Q38R		.89					
Q20R		.79					
Q45R		.69					
Q2			.80				
Q10			.55				
Q13			.72				
Q41			.48				
Q27			.39				
Q32			.60				
Q8			.51				
Q29R				.86			
Q30R				.79			
Q31R				.76			
Q5					.61		
Q22					.80		
Q15					.51		
Q19					.68		
Q25R					.43		
Q6R						.41	
Q14R						.78	
Q21R						.42	
Q43R						.54	
Q1							.82
Q7							.75

Table 5.40 Variances Explained by the Factors

Factor	Variances explained
F1 (Process Satisfaction)	1.99
F2 (Perceived Learning)	2.14
F3 (Perceived Intellectual Synergy)	1.83
F4 (Cohesiveness)	1.56
F6 (Perceived Equality of Participation)	1.79
F7 (Outcome Satisfaction)	1.36
F8 (Evaluation Apprehension)	1.48
Final Communality Estimates	18.30

The level of internal consistency reliability of each construct (factor) was measured using Cronbach's alpha (See Table 5.41 for the result). Only the constructs of which Cronbach's alpha is greater than 0.7 (Perceived Intellectual Synergy, Perceived Learning, Process Satisfaction and Cohesiveness) were considered reliable and their groups means would be analyzed in the further analysis. Table 5.42 represents these questionnaire items which would be included in the further analysis.

Table 5.41 Scale Reliability

Question Items	Cronbach Alpha	Reliability
Evaluation Apprehension	0.55	Not Reliable
Perceived Intellectual Synergy	0.76	Reliable
Perceived Learning	0.83	Reliable
Perceived Equality of Participation	0.66	Not Reliable
Cohesiveness	0.85	Reliable
Process Satisfaction	0.88	Reliable
Outcome Satisfaction	0.63	Not Reliable
Perceived Group Performance	0.52	Not Reliable

Table 5.42 Post-Experiment Questionnaire Items To Be Analyzed

Measure	Item Number	Question / Statement
Perceived Intellectual Synergy	2	This group process emphasized the value of questioning assumptions. (Not at all / Very much)
	10	This group process got me to look at problems from many different angles. (Not at all / Very much)
	13	This group process made me re-examine critical assumptions to question whether they are appropriate. (Not at all / Very much)
	41	This group process encouraged addressing problems by using reasoning and evidence, rather than unsupported opinion. (Not at all / Very much)
	27	This group process encouraged me to express my ideas and opinions. (Not at all / Very much)
	32	This group process encouraged us to rethink ideas which had never been questioned before. (Not at all / Very much)
	8	This group process sought differing perspectives when solving problems. (Not at all / Very much)
Perceived Learning	18	After this group process, I developed the ability to communicate clearly about the topic.
	11	After this group process, I gained a good understanding of the subject area of object tracking technologies and their applications.
	26	After this group process, I learned to identify central issues in the area of object tracking technologies and their applications.
	38	After this group process, my skill in critical thinking was increased.
	20	After this group process, I learned a great deal of factual information about the subject area of object tracking technologies and their applications.
	45	After this group process, I became more interested in the subject area of object tracking technologies and their applications.
Process Satisfaction	33	Efficient / Inefficient
	34	Coordinated / Uncoordinated
	35	Fair / Unfair
	36	Understandable / Confusing
	37	Satisfying / Unsatisfying
Cohesiveness	29	The way people get along together
	30	The way people work together
	31	The way people help each other

5.2.2 Inter-Rater Reliability Test

5.2.2.1 Reliability of Idea Importance Ratings. To test the inter-rater reliability of the measure rated by the expert judges, Pearson correlation coefficient R was calculated. The results of judge evaluation of the importance of ideas were coded into scores 1 to 7, 7 denotes "Excellent or Outstanding Importance" and 1 denotes "Useless or Not Important". For this scheme, higher score denotes higher importance. Table 5.43 shows the coding of the importance scale.

Table 5.43 Coding Scheme for Importance

	Scale	Score
A	Excellent or Outstanding Importance	7
B+	Very Important	6
B	Important	5
C+	Above Average Importance	4
C	Average Importance	3
D	Slightly Important	2
F	Useless or Not Important	1

Table 5.44 shows the descriptive statistics of this result. To test inter-rater reliability among the judges, Pearson correlation coefficient R was calculated and Table 5.45 includes the result. This result shows that the correlations among the three faculty judges (Judge 1, 2 and 3) were higher (0.36 – 0.37) than the correlations among the all judges including the other two Ph.D. student judges (Judge 4 and 5) (0.03 – 0.24). Therefore, The importance of ideas were judged by two separate measures, the average ratings of all of the five judges (Importance of Ideas by All Judges) and the average of ratings of the three faculty judges (Judge 1, Judge 2 and Judge 3) (Importance of Ideas by Faculty Judges).

Table 5.44 Descriptive Statistics of Importance

Judge	Mean	SD	Sum	Min	Max
Judge 1	3.99	1.25	842.00	1	7
Judge 2	3.33	1.40	705.00	1	7
Judge 3	3.29	1.65	697.00	1	7
Judge 4	4.87	1.36	1033.00	1	7
Judge 5	4.65	1.27	968.00	2	7

Table 5.45 Pearson R for Importance

	Judge 1	Judge 2	Judge 3	Judge 4	Judge 5
Judge 1		0.37	0.36	0.23	0.24
Judge 2	0.37		0.37	0.24	0.12
Judge 3	0.36	0.37		0.16	0.03
Judge 4	0.23	0.24	0.16		0.21
Judge 5	0.24	0.12	0.03	0.21	

5.2.2.2 Reliability of Idea Creativity Ratings. The results of judge evaluation of the creativity of ideas were coded into scores 1 to 7, 7 denotes "Exceptionally Creative" and 1 denotes "Not Creative". For this scheme, higher score denotes higher creativity. Table 5.46 shows the coding of the importance scale.

Table 5.46 Coding Scheme for Creativity

	Scale	Score
A	Exceptionally Creative	7
B+	Very Creative	6
B	Creative	5
C+	Above Average Creative	4
C	Average Creativity	3
D	Slightly Creative	2
F	Not Creative	1

Table 5.47 shows the descriptive statistics of this result. To test inter-rater reliability among the judges, Pearson correlation coefficient R was calculated and Table 5.48 includes the result. Similar to the case of Importance, This result shows that the correlations among the three faculty judges (Judge 1, 2 and 3) were higher (0.35 – 0.40) than the correlations among the all judges including the other two Ph.D. student judges (Judge 4 and 5) (0.09 – 0.30). Therefore, The creativity of ideas were judged by two separate measures, the average ratings of all of the five judges (Creativity of Ideas by All Judges) and the average of ratings of the three faculty judges (Judge 1, Judge 2 and Judge 3) (Creativity of Ideas by Faculty Judges).

Table 5.47 Descriptive Statistics of Creativity

Judge	Mean	SD	Sum	Min	Max
Judge 1	4.39	1.24	927.00	1	7
Judge 2	3.58	1.40	759.00	1	7
Judge 3	2.33	1.22	497.00	1	6
Judge 4	3.82	2.14	809.00	1	7
Judge 5	3.52	1.48	732.00	1	7

Table 5.48 Pearson R for Creativity

	Judge 1	Judge 2	Judge 3	Judge 4	Judge 5
Judge 1		0.40	0.38	0.09	0.22
Judge 2	0.40		0.35	0.09	0.23
Judge 3	0.38	0.35		0.10	0.30
Judge 4	0.09	0.09	0.10		0.15
Judge 5	0.22	0.23	0.30	0.15	

5.2.2.3 Reliability of Group Report Quality Ratings. Each criterion (quality of ideas, quality of positive consequences, quality of negative consequences, presentation quality) was evaluated in terms of the seven scales; A: Excellent / Outstanding, B+: Very Good, B: Good, C+: Above Average, C: Average, D: Below Average, F: Very Poor. The rating of each criterion was coded into scores 1 to 7, 1 denotes “Useless or Not Important” and 7 denotes “Excellent / Outstanding”. For this scheme, higher score denotes higher quality. Table 5.49 shows the coding of this scale.

Table 5.49 Coding Scheme for Group Report Quality

	Scale	Score
A	Excellent / Outstanding	7
B+	Very Good	6
B	Good	5
C+	Above Average	4
C	Average	3
D	Below Creative	2
F	Very Poor	1

The same weight was given to the three sub-criteria in the evaluation of the content. Then, the ratings of content and presentation quality were averaged to calculate the overall quality.

Overall Quality of Group Report
= Average(Average(quality of ideas, quality of positive consequences, quality of negative consequences), Presentation Quality)

Table 5.50 shows the descriptive statistics of the content quality. To test inter-rater reliability among the judges, Pearson correlation coefficient R was calculated and Table 5.51 includes the result. For this criteria, Pearson R among the judges were in the range of 0.48 - 0.77.

Table 5.50 Descriptive Statistics of Content Quality

Judge	Mean	Std	Sum	Minimum	Maximum
Judge 1	3.19	0.94	140.33	1.33	5.00
Judge 2	4.45	1.71	196.00	1.00	7.00
Judge 3	3.84	0.94	169.00	2.33	6.00
Judge 4	4.42	1.61	194.33	1.00	6.67

Table 5.51 Pearson R for Content Quality

	Judge 1	Judge 2	Judge 3	Judge 4
Judge 1		0.52	0.64	0.48
Judge 2	0.52		0.77	0.61
Judge 3	0.64	0.77		0.56
Judge 4	0.48	0.61	0.56	

Table 5.52 shows the descriptive statistics of the presentation quality. To test inter-rater reliability among the judges, Pearson correlation coefficient R was calculated and Table 5.53 includes the result. For this criteria, Pearson R among the judges were in the range of 0.35 - 0.59.

Table 5.52 Descriptive Statistics of Presentation Quality

Judge	Mean	Std	Sum	Minimum	Maximum
Judge 1	3.68	1.07	162.00	2.00	6.00
Judge 2	4.59	1.94	202.00	1.00	7.00
Judge 3	4.86	0.90	214.00	3.00	6.00
Judge 4	4.50	1.61	198.00	1.00	7.00

Table 5.53 Pearson R for Presentation Quality

	Judge 1	Judge 2	Judge 3	Judge 4
Judge 1		0.45	0.36	0.35
Judge 2	0.45		0.48	0.59
Judge 3	0.36	0.48		0.55
Judge 4	0.35	0.59	0.55	

Table 5.54 shows the descriptive statistics of the overall quality. To test inter-rater reliability among the judges, Pearson correlation coefficient R was calculated and Table 5.55 includes the result. For this criteria, Pearson R among the judges were in the range of 0.44 - 0.70.

Table 5.54 Descriptive Statistics of Overall Report Quality

Judge	Mean	Std	Sum	Minimum	Maximum
Judge 1	3.44	0.98	151.17	1.67	5.50
Judge 2	4.52	1.77	199.00	1.00	7.00
Judge 3	4.35	0.79	191.50	2.67	6.00
Judge 4	4.46	1.56	196.17	1.17	6.83

Table 5.55 Pearson R for Overall Report Quality

	Judge 1	Judge 2	Judge 3	Judge 4
Judge 1		0.51	0.60	0.44
Judge 2	0.51		0.70	0.64
Judge 3	0.60	0.70		0.63
Judge 4	0.44	0.64	0.63	

5.2.3 Goodness of Fit Test for Normal Distribution and Data Transformation

The use of parametric analysis methods for measures requires the assumptions for normal distribution. The goodness of fit test for normal distribution was done using Kolmogorov-Smirnov D. The significant level p=0.01 was used to test the null hypothesis of fitting into normal distribution Table 5.56 shows the results of the goodness of fit test for normal distribution the sample.

Table 5.56 Results of Goodness of Fit Tests for Normal Distribution of the Sample

Measure	Kolmogorov -Smirnov D	p Value	Ho: Sample distribution fit into normal distribution (at significance level p=0.01)
Perceived Intellectual Synergy	0.12	.122	Not rejected
Perceived Learning	0.10	>.15	Not rejected
Total Word Count	0.14	.021	Not rejected
Per person word count	0.07	>.15	Not rejected
Word count of group coordinator	0.16	<.01	Rejected
Inequality of Participation by Word count	0.13	.049	Not rejected
Inequality of Participation by Number of Raw Ideas	0.19	<.01	Rejected
Number of Total Raw Ideas	0.47	<.01	Rejected
Number of Per Person Raw Ideas	0.08	>.15	Not rejected
Number of Total Unique Ideas in Discussion	0.15	.013	Not rejected
Number of Unique Ideas Per Person in Discussion	0.09	>.15	Not rejected
Number of Total Unique Ideas in Report	0.16	<.01	Rejected
Number of Per Person Unique Ideas in Report	0.15	.016	Not rejected
Number of Total Rare Ideas appearing in One Group	0.12	.087	Not rejected
Number of Per Person Rare Ideas appearing in One Group	0.12	.092	Not rejected
Number of Total Rare Ideas appearing in One or Two Groups	0.14	.028	Not rejected
Number of Per Person Rare Ideas appearing in One or Two Groups	0.17	<.01	Rejected
Number of Total Rare Ideas appearing in One, Two, or Three Groups	0.07	>.15	Not rejected
Number of Per Person Rare Ideas appearing in One, Two, or Three Groups	0.18	<.01	Rejected
Importance of Ideas by All Judges	0.13	.063	Not Rejected
Importance of Ideas by Faculty Judges	0.13	.083	Not Rejected
Creativity of Ideas By All Judges	0.13	.056	Not rejected
Creativity of Ideas By Faculty Judges	0.16	<.01	Rejected
Content Qualityof Report	0.11	>.15	Not rejected
Presentation Quality of Report	0.09	>.15	Not rejected
Overall Group Report Quality	0.11	>.15	Not rejected
Process Satisfaction	0.12	>.122	Not rejected
Cohesiveness	0.10	>.15	Not rejected
Efficiency of Unique Idea Production	0.15	>.15	Not rejected
Efficiency of Rare Idea Production (Rare Ideas appearing in One Group)	0.06	>.15	Not rejected
Efficiency of Rare Idea Production (Rare Ideas appearing in One or Two Groups)	0.06	>.15	Not rejected
Efficiency of Rare Idea Production (Rare Ideas appearing in One, Two, or Three Groups)	0.07	>.15	Not rejected

Data transformations were done for the measures which failed the goodness fit test were transformed (which rejected the null hypothesis). Transformation types were chosen based on the characteristics of the data. Number of Per Person Raw Ideas, Inequality by Raw Ideas, Number of Unique Ideas in Report, Number of Per Person Rare Ideas appearing in One or Two Groups, Number of Per Person Rare Ideas appearing in One, Two, or Three Groups, Creativity by Faculty Judges and Group Coordinator Word Count was transformed into the form of square root. Then the transformed measures were tested against the goodness of fit for normal distribution and the distributions of these three transformed measures were not significantly different from normal distribution at significance level p=.01 (See Table 5.57).

Table 5.57 Results of Goodness of Fit Tests for Normal Distribution of the Transformed Measures

Measure	Kolmogorov-Smirnov D	p Value	Ho: Sample distribution fit into normal distribution (at significance level p=0.01)
SQRT (Number of Per Person Raw Ideas)	0.09	>.15	Not Rejected
SQRT (Inequality of Participation by Number of Raw Ideas)	0.15	.014	Not Rejected
SQRT (Number of Total Unique Ideas in Report)	0.12	.141	Not Rejected
SQRT (Number of Per Person Rare Ideas appearing in One or Two Groups)	0.11	>.15	Not Rejected
SQRT (Number of Per Person Rare Ideas appearing in One, Two, or Three Groups)	0.13	.078	Not Rejected
SQRT (Creativity by Faculty Judges)	0.15	.014	Not Rejected
SQRT (Word Count of Group Coordinator)	0.10	>.15	Not Rejected

5.3 Chapter Summary

The cross tabulation of each demographic characteristic with Chi-square statistics in Section 5.1 shows that the subjects were randomly assigned in different conditions so that the samples in each condition are essentially "the same" in terms of their characteristics. The cross tabulation analysis of the subjects' responses to the task questionnaire in Section 5.2 shows that the subjects in Delphi groups had more difficulty to comprehend the task even though the groups in both conditions were given exactly the same task. Among the Post-Experiment Questionnaire items, Perceived Depth of Evaluation (H2), Perceived Free-Riding (H4), Evaluation Apprehension (H5), Perceived Equality of Participation (H9), and Outcome Satisfaction (H20) were removed from further analysis due to the lack of the validity and the reliability demonstrated in Sub-section 5.2.1. Seven measures (Number of Per Person Raw Ideas, Inequality by Raw Ideas, Number of Unique Ideas in Report, Number of Per Person Rare Ideas appearing in One or Two Groups, Number of Per Person Rare Ideas appearing in One, Two, or Three Groups, Creativity by Faculty Judges and Group Coordinator Word Count) were transformed to the form of square root to comply with the fit to the normal distribution. Table 5.58 summarizes the validated measures after completing the index validation.

Table 5.58 Validated Measures

Category	Variables		Measurement
Process Gain / Loss (Intervening Variables)	Perceived Intellectual Synergy (H1)		7 Post-Experiment Questionnaire items
	Perceived Depth of Evaluation (H2)		Removed
	Perceived Learning (H3)		6 Post-Experiment Questionnaire items
	Perceived Free-riding (H4)		Removed
	Evaluation Apprehension (H5)		Removed
	Participation	Total Word Count (H6)	The total word count by all members
		Per Person Word Count (H7)	Total Word Count / Number of Actual Participants
		Coordinator Word Count (H8)	SQRT (The word count by the group coordinator)
	Inequality of (H9) Participation	Perceived equality of participation	Removed
		Inequality of participation by Word Count	Normalized standard deviation of the word count
		Inequality of Participation by Number of Raw Ideas	SQRT (Normalized standard deviation of the number of raw ideas)
Effectiveness (Dependent Variables)	Number of Raw Ideas	Number of Total Raw Ideas (H10)	The total number of ideas including duplications
		Number of Per Person Raw Ideas (H12)	SQRT (Number of Total Raw Ideas / Number of Actual Participants)
	Number of unique ideas	Number of Total Unique Ideas in Discussion (H11)	The number of unique ideas appearing in the Webboard conference
		Number of Total Unique Ideas in Report (H11)	SQRT (The number of unique ideas appearing in the group report)
		Number of Per Person Unique Ideas in Discussion (H13)	Number of Total Unique Ideas in Discussion / Number of Actual Participants
		Number of Per Person Unique Ideas in Report (H13)	Number of Total Unique Ideas in Report / Number of Actual Participants

Table 5.58 Validated Measures (Continued)

Category	Variables		Measurement
Effectiveness (Dependent Variables)	Number of Rare Ideas	Number of Total Rare Ideas appearing in One Group (H15)	The number of ideas only appearing in one group
		Number of Total Rare Ideas appearing in One or Two Groups (H15)	The number of ideas appearing in no more than two groups
		Number of Total Rare Ideas appearing in One, Two, or Three Groups (H15)	The number of ideas appearing in no more than three groups
		Number of Per Person Rare Ideas appearing in One Group (H16)	Number of Total Rare Ideas appearing in One Group / Number of Actual Participants
		Number of Per Person Rare Ideas appearing in One or Two Groups (H16)	SQRT (Number of Total Rare Ideas appearing in One or Two Groups / Number of Actual Participants)
		Number of Per Person Rare Ideas appearing in One, Two, or Three Groups (H16)	SQRT (Number of Total Rare Ideas appearing in One, Two, or Three Groups / Number of Actual Participants)
	Importance of Ideas (H14)	Importance of Ideas By All Judges	Average ratings of the five expert judges (3 faculty members and 2 Ph.D. students)
		Importance of Ideas By Faculty Judges	Average ratings of the three expert judges of faculty members
	Creativity of Ideas (H17)	Creativity of Ideas By All Judges	Average ratings of the five expert judges (3 faculty members and 2 Ph.D. students)
		Creativity of Ideas By Faculty Judges	SQRT (Average ratings of the three expert judges of faculty members)
	Quality of group report (H18)	Content Quality	Average ratings of the expert judges
		Presentation Quality	Average ratings of the expert judges
		Overall Report Quality	Average of Content Quality and Presentation Quality
Satisfaction (Dependent Variables)	Process satisfaction (H19)		5 Post-Experiment Questionnaire items
	Outcome satisfaction (H20)		Removed
	Cohesiveness (H21)		3 Post-Experiment Questionnaire items

Table 5.58 Validated Measures (Continued)

Category	Variables		Measurement
Supplementary Analysis	Efficiency of Idea Production	Efficiency of Unique Idea Production	Number of Total Unique Ideas in Discussion / Number of Total Raw Ideas in Discussion
		Efficiency of Rare Idea Production (Rare Ideas appearing in One Group)	Number of Total Rare Ideas appearing in One Group / Number of Unique Ideas in Discussion
		Efficiency of Rare Idea Production (Rare Ideas appearing in One or Two Groups)	Number of Total Rare Ideas appearing in One or Two Groups / Number of Unique Ideas in Discussion
		Efficiency of Rare Idea Production (Rare Ideas appearing in One, Two, or Three Groups)	Number of Total Rare Ideas appearing in One, Two, or Three Groups / Number of Unique Ideas in Discussion

CHAPTER 6

TESTS OF HYPOTHESES AND SUPPLEMENTARY ANALYSIS

Section 6.1 discusses the results of statistical tests of the hypotheses. Section 6.2 covers the results of the supplementary analysis for the efficiency of unique and rare ideas productions. Section 6.3 discusses the results of the analysis of correlations among variables. The conclusions of this study are drawn from the findings of the sections 6.1, 6.2, and 6.3 are discussed in Section 6.4.

6.1 Tests of Hypothesis

6.1.1 Process Gains / Losses

Among the process gains/losses proposed, Perceived Depth of Evaluation (H2), Perceived Free-Riding (H4), Evaluation Apprehension (H5) and Perceived Equality of Participation (H9) were removed in Section 5.1 and the following four measures were analyzed.

6.1.1.1 Perceived Intellectual Synergy. Perceived intellectual synergy was measured by seven Post-Experiment Questionnaire items and higher values denote higher level. Table 6.1 shows the means and standard deviation of this measure. ANOVA shows that there are no significant differences between conditions (See Table 6.2).

Table 6.1 Means / Standard Deviations of Perceived Intellectual Synergy

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(23.31, 2.26)	(23.20, 2.08)	(23.26, 2.12)
Unstructured	(22.92, 2.78)	(23.63, 1.76)	(23.28, 2.30)
Total	(23.12, 2.48)	(23.42, 1.89)	(23.27, 2.19)

Table 6.2 ANOVA of Perceived Intellectual Synergy

Source	**(F, df)**	**Pr>F**
Structure	(0.00, 1)	0.9776
Group Size	(0.19, 1)	0.6621
Structure*Group Size	(0.36, 1)	0.5520

The above results indicate:

H1a. The Delphi groups will perceive a higher level of intellectual synergy than the unstructured asynchronous groups.
Not Supported

H1b. The medium-sized groups will perceive a higher level of intellectual synergy than the small-sized groups.
Not Supported

H1c. Communication structure interacts with group size so that the medium-sized Delphi groups will perceive disproportionately higher level of intellectual synergy than the small-sized Delphi groups.
Not Supported

6.1.1.2 Perceived Learning. Perceived learning was measured by six Post-Experiment Questionnaire items and higher values denote higher level. Table 6.3 shows the means and standard deviation of this measure. As shown in Table 6.4, there were no significant differences between conditions.

Table 6.3 Means/ Standard Deviations of Perceived Learning

(Mean, SD)	**Small-sized**	**Medium-sized**	**Total**
Delphi	(20.33, 2.60)	(20.64, 1.51)	(20.48, 2.08)
Unstructured	(20.19, 1.93)	(20.22, 1.37)	(20.20, 1.63)
Total	(20.26, 2.24)	(20.43, 1.42)	(20.34, 1.86)

Table 6.4 ANOVA of Perceived Learning

Source	**(F, df)**	**Pr>F**
Structure	(0.24, 1)	0.6294
Group Size	(0.09, 1)	0.7685
Structure*Group Size	(0.06, 1)	0.8038

From the above findings,

H3a. The Delphi groups will perceive a higher level of learning effect than the

unstructured asynchronous groups.
Not Supported

H3b. The medium-sized groups will perceive a higher level of learning effect than the small-sized groups.
Not Supported

H3c. Communication structure interacts with group size so that the medium-sized Delphi groups will perceive disproportionately higher level of learning effect than the small-sized Delphi groups.
Not Supported

6.1.1.3 Participation. In terms of participation, the level of participation was tested using two different measures—Total Word Count and Per Person Word Count. The word count of the group coordinator was also tested to see whether there are differences among conditions.

Total Word Count

The ANOVA for Total Word Count showed that the medium-sized groups (mean=14980.77) posted significantly (p<.0001) more total words in the Webboard conference than the small-sized groups (mean=8405.77). However, different from the prediction, there was no significant (p=.7107) difference between Delphi groups (mean=11421.55) and the unstructured groups (mean=11965.00) (See Table 6.5 and Table 6.6). Therefore,

H6a. The Delphi groups will participate more in discussion than the unstructured asynchronous groups.
Not Supported

H6b. The medium-sized groups will participate more in discussion than the small-sized groups.
Supported

Table 6.5 Means/ Standard Deviations of Total Word Count

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(9164.00, 3371.75)	(13679.09, 5054.43)	(11421.55, 4787.30)
Unstructured	(7647.55, 2719.19)	(16282.45, 6985.92)	(11965.00, 6803.57)
Total	(8405.77, 3088.19)	(14980.77, 6097.54)	(11693.27, 5820.16)

Table 6.6 ANOVA of Total Word Count

Source	(F, df)	P > F
Process	(0.14, 1)	.7107
Group Size	(20.43, 1)***	<.0001
Process*Group Size	(2.01, 1)	.1645

Per Person Word Count

The result of Per Person Word Count in Table 6.7 and Table 6.8 shows no significant differences between Delphi and unstructured groups (p=0.8958). Different from the case of Total Word Count, no significant difference was found between small-sized and medium-sized groups (p=0. 3843) in terms of the per person word count.

Table 6.7 Means/ Standard Deviations of Per Person Word Count

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(1547.92, 550.05)	(1181.17, 426.64)	(1364.54, 515.73)
Unstructured	(1295.21, 424.99)	(1393.68, 598.16)	(1344.45, 508.85)
Total	(1421.56, 496.80)	(1287.43, 518.54)	(1354.49, 506.41)

Table 6.8 ANOVA of Per Person Word Count

Source	(F, df)	P > F
Process	(0.02, 1)	.8958
Group Size	(0.77, 1)	.3843
Process*Group Size	(2.33, 1)	.1350

From the above results,

H7a. A person in a Delphi group will participate more in discussion than a person in an unstructured asynchronous group.
Not Supported

H7b. A person in a small-sized group will participate more in discussion than a person in a medium-sized group.
Not Supported

Group Coordinator Word Count

For this measure, a transformed form, SQRT(Coordinator Word Count), was used to test the hypotheses and Table 6.9 shows the means and standard deviations for this measure. Table 6.10 shows that there is no significant differences between Delphi and unstructured groups (p=0.1581) or between small-sized and medium-sized groups (p=0.3268), in terms of this measure. There is no significant interaction effect between the structure and the group size (p=.4613).

Table 6.9 Means/ Standard Deviations of SQRT(Group Coordinator Word Count)

(Mean, SD)	Small	Large	Total
Delphi	(45.79, 14.87)	(47.05, 13.13)	(46.42, 13.71)
Non-Delphi	(49.32, 13.60)	(58.16, 23.68)	(53.74, 19.38)
Total	(47.56, 14.03)	(52.61, 19.53)	(50.08, 17.00)

Table 6.10 ANOVA of SQRT(Group Coordinator Word Count)

Source	(F, df)	Pr>F
Structure	(2.07, 1)	.1581
Group Size	(0.99, 1)	.3268
Structure*Group Size	(0.55, 1)	.4613

Therefore,

H8a. The group coordinator in an unstructured asynchronous group will participate more in discussion than the group coordinator in a Delphi group.
Not Supported

H8b. The group coordinator in a medium-sized group will participate more in discussion than the group coordinator in a small-sized group.
Not Supported

H8c. Communication structure interacts with group size so that the group coordinator of the medium-sized unstructured groups will participate disproportionately more in discussion than the group coordinator of the small-sized unstructured groups.
Not Supported

6.1.1.4 Inequality of Participation. For the measure of Inequality of Participation by Word Count, lower values denote more equal participation among group members. Table 6.11 shows the means and standard deviation of this measure. Also Table 6.12 shows the results of ANOVA. Members of the Delphi groups (mean=0.26) participated in discussion significantly (p=.0074) more equally than the members of the unstructured groups (mean=0.20) and this result supported the hypothesis. Also, the medium-sized groups (mean=0.20) participated in discussion significantly (p=.0346) more equally than the small-sized groups (mean=0.25) and this is the opposite direction to the original prediction. Considering the fact that the measure used in this study evaluates the medium-sized group slightly higher than the small-sized group (See Sub-section 4.8.6), this result can be considered very significant. There was no significant interaction effect found between structure and group size (p=0.3301).

Table 6.11 Means/ Standard Deviations of Inequality of Participation by Word Count

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(0.21, 0.06)	(0.19, 0.04)	(0.20, 0.05)
Unstructured	(0.29, 0.08)	(0.22, 0.10)	(0.26, 0.09)
Total	(0.25, 0.08)	(0.20, 0.07)	(0.23, 0.08)

Table 6.12 ANOVA of Inequality of Participation by Word Count

Source	(F, df)	Pr>F
Structure	$(7.96, 1)^{**}$	.0074
Group Size	$(4.79, 1)^{*}$	.0346
Structure*Group Size	(0.97, 1)	.3301

For the transformed form of Inequality of Participation by Number of Raw Ideas measure, lower values denote more equal participation among group members. Table 6.13 shows the means and standard deviation of this measure. The ANOVA (See Table 6.14) shows that the medium-sized groups (mean=0.45) participated in discussion significantly more equally than the small-sized groups (mean=0.50) in average, and this direction was same in the case of Inequality of Participation by Word count. However this difference was not significant (p=.1109). There was no significant (p=.7372) difference between Delphi (mean= 0.47) and the unstructured (p=0.48) groups. No interaction effect was found between structure and group size (p=.1332).

Table 6.13 Means/ Standard Deviations of SQRT(Inequality of Participation by Number of Raw Ideas)

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(0.47, 0.08)	(0.47, 0.05)	(0.47, 0.07)
Unstructured	(0.53, 0.14)	(0.43, 0.10)	(0.48, 0.13)
Total	(0.50, 0.11)	(0.45, 0.08)	(0.47, 0.10)

Table 6.14 ANOVA of SQRT(Inequality of Participation by Number of Raw Ideas)

Source	(F, df)	Pr>F
Structure	(0.11, 1)	.7372
Group Size	(2.66, 1)	.1109
Structure*Group Size	(2.35, 1)	.1332

Based on the above findings,

H9a. The unstructured asynchronous groups will participate in discussion less equally than the Delphi groups.
Supported (only on Inequality of Participation by Word Count)

H9b. The medium-sized groups will participate in discussion less equally than the small-sized groups.
Opposite Direction Supported (only on Inequality of Participation by Word Count)

H9c. Communication structure interacts with group size so that the small-sized Delphi groups will participate in discussion less equally than the medium-sized Delphi groups.
Not Supported (on either measure for Inequality of Participation)

6.1.2 Effectiveness

6.1.2.1 Number of Raw Ideas.

Number of Total Raw Ideas

Table 6.15 presents the means and standard deviations of Number of Total Raw Ideas and Table 6.16 present the results of ANOVA for Number of Total Raw Ideas. During the group discussion, Delphi groups (mean=18.73) produced significantly ($p<.0001$) more total raw ideas than unstructured groups (mean=13.27). Also, the medium-sized groups (mean=20.41) produced significantly ($p<.0001$) more total raw ideas than the small-sized groups (mean=11.59). No significant interaction effect was found between structure and group size (p=.9399).

Table 6.15 Means/ Standard Deviations of Number of Total Raw Ideas

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(14.27, 1.95)	(23.18, 5.67)	(18.73, 6.16)
Unstructured	(8.91, 2.12)	(17.64, 4.76)	(13.27, 5.73)
Total	(11.59, 3.39)	(20.41, 5.84)	(16, 6.50)

Table 6.16 ANOVA of Number of Total Raw Ideas

Source	(F, df)	Pr > F
Structure	(20.74, 1)***	<.0001
Group Size	(54.20, 1)***	<.0001
Structure*Group Size	(0.01, 1)	.9399

The above findings indicate the following;

H10a. The Delphi groups will produce more ***total raw ideas*** *than the unstructured asynchronous groups.*
Supported

H10b. The medium-sized groups will produce more total raw ideas than the small-sized groups.
Supported

H10c. Communication structure interacts with group size so that the medium-sized Delphi groups produce disproportionately more total raw ideas than the small-sized Delphi groups.
Not Supported

Number of Per Person Raw Ideas

Table 6.17 presents the means and standard deviations of SQRT(Number of Per Person Raw Ideas) and Table 6.18 present the results of ANOVA for SQRT(Number of Per Person Raw Ideas). During the group discussion, Delphi groups (mean=1.48) produced significantly (p<.0001) more per person raw ideas than unstructured groups (mean=1.22). Small-sized groups (mean=1.39) produced more per person raw ideas than medium-sized groups (mean=1.31) in average but not significantly so (p=.0789).

Table 6.17 Means/ Standard Deviations of SQRT (Number of Per Person Raw Ideas)

(Mean, SD)	**Small-sized**	**Medium-sized**	**Total**
Delphi	(1.55, 0.11)	(1.40, 0.17)	(1.48, 0.16)
Unstructured	(1.23, 0.15)	(1.22, 0.15)	(1.22, 0.15)
Total	(1.39, 0.21)	(1.31, 0.19)	(1.35, 0.20)

Table 6.18 ANOVA of SQRT (Number of Per Person Raw Ideas)

Source	**(F, df)**	Pr > F
Structure	(32.32, 1)***	<.0001
Group Size	(3.25, 1)	.0789
Structure*Group Size	(2.20, 1)	.1461

The above findings indicate the following;

H12a. The Delphi groups will produce more ***per person raw ideas*** *than the unstructured asynchronous groups.*
Supported

H12b. The small-sized groups will produce more per person raw ideas than the medium-sized groups.
Not Supported

H12c. Communication structure interacts with group size so that the medium-sized Delphi groups produce disproportionately more per person raw ideas than the small-sized Delphi groups.
Not Supported

6.1.2.2 Number of Unique Ideas.

Number of Total Unique Ideas

Table 6.19 and Table 6.20 present the result on Number of Unique Ideas in Discussion. During the group discussion, Delphi groups (mean=15.91) produced significantly ($p=0.002$) more unique ideas in the Webboard discussion conference than unstructured groups (mean=11.82). Also, Medium-sized groups (mean=17.36) produced significantly ($p<0.0001$) more unique ideas than small-sized groups (mean=10.36). However, no significant interaction effect was found between structure and group size ($p=0.7145$).

Table 6.19 Means/ Standard Deviations of Number of Total Unique Ideas in Discussion

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(12.64, 1.96)	(19.18, 5.96)	(15.91, 5.48)
Unstructured	(8.09, 2.34)	(15.55, 4.70)	(11.82, 5.26)
Total	(10.36, 3.14)	(17.36, 5.56)	(13.86, 5.70)

Table 6.20 ANOVA of Number of Total Unique Ideas in Discussion

Source	(F, df)	Pr > F
Structure	$(10.99, 1)^{**}$	.002
Group Size	$(32.19, 1)^{***}$	<.0001
Structure*Group Size	(0.14, 1)	.7145

Table 6.21 and Table 6.22 present the result on Number of Unique Ideas in Report. The reports of the Delphi groups (mean=3.63) included significantly (p=0.0042) more unique ideas than the reports of the unstructured groups (mean=3.04). Also, the reports of the medium-sized groups (mean=3.73) included significantly (p=0.0001) more unique ideas than the reports of the small-sized groups (mean=2.92). However, no significant interaction effect was found between structure and group size (p=0.6956).

Table 6.21 Means/ Standard Deviations of SQRT(Number of Total Unique Ideas in Report)

(Mean, Sdv)	Small-sized	Medium-sized	Total
Delphi	(3.25, 0.45)	(4.00, 0.70)	(3.63, 0.69)
Unstructured	(2.58, 0.51)	(3.49, 0.84)	(3.04, 0.82)
Total	(2.92, 0.58)	(3.75, 0.80)	(3.33, 0.81)

Table 6.22 ANOVA of SQRT(Number of Total Unique Ideas in Report)

Source	(F, df)	Pr > F
Structure	$(9.20, 1)^{**}$	.0042
Group Size	$(18.33, 1)^{**}$	.0001
Structure*Group Size	(0.16, 1)	.6956

The above results indicate the followings:

H11a.The Delphi groups will produce more ***total unique ideas*** *than the unstructured asynchronous groups.*

Supported

H11b. The medium-sized groups will produce more total unique ideas than the small-sized groups.
Supported

H11c. Communication structure interacts with group size so that the medium-sized Delphi groups produce disproportionately more total unique ideas than the small-sized Delphi groups.
Not Supported

Number of Per Person Unique Ideas

Table 6.23 and Table 6.24 show the results on Number of Per Person Unique Ideas in Discussion. During the group discussion, Delphi groups (mean=1.90) produced significantly ($p<0.0001$) more unique ideas per person in the Webboard discussion conference than unstructured groups (mean=1.36). Also, small-sized groups (mean=1.77) generated significantly ($p<0.0249$) more unique ideas per person than medium-sized groups (mean=1.49). The small-sized Delphi groups disproportionately more unique ideas per person in discussion than the medium-sized Delphi groups but this interaction effect was not significant ($p=0.0948$). Also this direction was opposite to the prediction.

Table 6.23 Means/ Standard Deviations of Number of Per Person Unique Ideas in Discussion

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(2.15, 0.36)	(1.65, 0.47)	(1.90, 0.48)
Unstructured	(1.40, 0.41)	(1.32, 0.38)	(1.36, 0.39)
Total	(1.77, 0.54)	(1.49, 0.45)	(1.63, 0.51)

Table 6.24 ANOVA of Number of Per Person Unique Ideas in Discussion

Source	(F, df)	Pr > F
Structure	$(19.26, 1)^{***}$	<.0001
Group Size	$(5.43, 1)^{*}$	.0249
Structure*Group Size	(2.93, 1)	.0948

Table 6.25 and Table 6.26 show the results on Number of Ideas Per Person in Report. The report of the Delphi group (mean=1.61) included significantly (p=0.0015) more unique ideas per person than the report of the unstructured group (mean=1.14). The report of the medium-sized group (mean=1.50) included more unique ideas per person in average than the report of the small-sized group (mean=1.25), but not significantly (p=0.0773) so. However, no significant interaction effect was found between structure and group size (p=0. 2923).

Table 6.25 Means/ Standard Deviations of Number of Per Person Unique Ideas in Report

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(1.82, 0.47)	(1.41, 0.42)	(1.61, 0.48)
Unstructured	(1.19, 0.48)	(1.09, 0.48)	(1.14, 0.47)
Total	(1.50, 0.56)	(1.25, 0.47)	(1.38, 0.53)

Table 6.26 ANOVA of Number of Per Person Unique Ideas in Report

Source	(F, df)	Pr > F
Structure	(11.60, 1)**	.0015
Group Size	(3.29, 1)	.0773
Structure*Group Size	(1.14, 1)	.2923

The above findings indicate the following;

H12a. The Delphi groups will produce more ***per person unique ideas*** *than the unstructured asynchronous groups*
Supported (only on Per Person Unique Ideas in Discussion)

H12b. The small-sized groups will produce more per person unique ideas than the medium-sized groups.
Supported (on both measures for per person unique ideas)

H12c. Communication structure interacts with group size so that the medium-sized Delphi groups produce disproportionately more per person unique ideas than the small-sized Delphi groups.
Not Supported (on either measure for per person unique ideas)

6.1.2.3 Number of Rare Ideas.

Number of Total Rare Ideas

The rare ideas were defined at the three levels of the rarity. Among the unique ideas the group produced, the ideas which appeared only in the corresponding group were identified and counted as "Number of Total Rare Ideas appearing in One Group." Table 6.27 shows the mean and standard deviation and Table 6.28 shows the result of the ANOVA for this measure. Comparing to the unstructured groups (mean=2.23), the Delphi groups produced more total rare ideas (mean=3.05) which were exclusive to one group, in terms of average. However this effect was not statistically significant (p=0.0973). However, the medium-sized groups (mean=3.50) produced significantly (p=0.0009) more total rare ideas than the small-sized groups (mean=1.77). In terms of the interaction effect, there was no significance found (p=0.1391).

Table 6.27 Means/ Standard Deviations of Number of Total Rare Ideas Appearing in One Group

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(2.55, 1.86)	(3.55, 2.16)	(3.05, 2.03)
Unstructured	(1.00, 0.77)	(3.45, 1.21)	(2.23, 1.60)
Total	(1.77, 1.60)	(3.50, 1.71)	(2.64, 1.86)

Table 6.28 ANOVA of Number of Total Rare Ideas Appearing in One Group

Source	(F, df)	Pr>F
Structure	(2.88, 1)	.0973
Group Size	(12.85, 1)***	.0009
Structure*Group Size	(2.28, 1)	.1391

Extending the level of the rarity to the next, the number of rare ideas of which ownership was shared with one additional group was counted and added to the above measure "Number of Total Rare Ideas appearing One Group" (=Number of Total Rare Ideas appearing One or Two Group). Table 6.29 shows the mean and standard deviation and Table 6.30 shows the result of the ANOVA for this measure. In terms of this level of rarity, Delphi groups produced significantly (p=0.0409) more total rare ideas (mean=3.98) than unstructured groups (mean=2.84). Medium-sized groups (mean=4.34) produced significantly (p=0.0013) more total rare ideas than small-sized groups (mean=2.48). However no significant interaction effect was found between structure and group size (p=0.1391).

Table 6.29 Means/ Standard Deviations of Number of Total Rare Ideas Appearing in One or Two Groups

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(3.36, 1.76)	(4.59, 2.65)	(3.98, 2.29)
Unstructured	(1.59, 0.83)	(4.09, 1.38)	(2.84, 1.69)
Total	(2.48, 1.62)	(4.34, 2.08)	(3.41, 2.07)

Table 6.30 ANOVA of Number of Total Rare Ideas Appearing in One or Two Groups

Source	(F, df)	Pr>F
Structure	(4.46, 1)*	.0409
Group Size	(12.01, 1)**	.0013
Structure*Group Size	(1.40, 1)	.2437

Finally, the unique ideas which were shared with two additional groups were identified and the number was added to the measure "Number of Total Rare Ideas appearing One or Two Group" (=Number of Total Rare Ideas appearing One, Two, or Three Groups). Table 6.31 shows the mean and standard deviation and Table 6.32 shows the result of the ANOVA for this measure. In terms of this level of rarity, Delphi groups produced significantly (p=0.018) more total rare ideas (mean=4.39) than unstructured groups (mean=3.02). Medium-sized groups (mean=4.75) produced significantly (p=0.0005) more total rare ideas than small-sized groups (mean=2.66). However no significant interaction effect was found between structure and group size (p=0.2916).

Table 6.31 Means/ Standard Deviations of Number of Total Rare Ideas Appearing in One, Two, or Three Groups

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(3.64, 1.87)	(5.14, 2.71)	(4.39, 2.40)
Unstructured	(1.68, 0.85)	(4.36, 1.37)	(3.02, 1.77)
Total	(2.66, 1.73)	(4.75, 2.14)	(3.70, 2.19)

Table 6.32 ANOVA of Number of Total Rare Ideas Appearing in One, Two, or Three Groups

Source	(F, df)	Pr>F
Structure	(6.08, 1)*	.0180
Group Size	(14.30, 1)***	.0005
Structure*Group Size	(1.14, 1)	.2916

The above findings suggest that the medium-sized groups produced more rare ideas than the small groups at all the three levels of the rarity. The Delphi groups produced significantly more rare ideas than the unstructured groups at the two levels of the rarity and the average of the total rare ideas appearing in one group also held the same direction at p=.0973. Therefore,

H15a. The Delphi groups will produce more total rare ideas than the unstructured asynchronous groups.
Supported (on Number of Total Rare Ideas Appearing in One or Two groups and Number of Total Rare Ideas Appearing in One, Two, or Three Groups)

H15b. The medium-sized groups will produce more total rare ideas than the small-sized groups.
Supported (on all of the three measures for the number of total rare ideas)

H15c. Communication structure interacts with group size so that the medium-sized Delphi groups produce disproportionately more total rare ideas than the small-sized Delphi groups.
Not Supported (on either of the three measures for the number of total rare ideas)

Number of Per Person Rare Ideas

The number of total number of rare ideas was divided by the number of actual participants for calculating the number of per person rare ideas. Table 6.33 presents the means and the standard deviations of the measure "Number of Per Person Rare Ideas appearing in One Group." The results of ANOVA for this measure were shown as Table 6.34. The results shows that the Delphi groups (mean=0.37) produced significantly (p=.0340) more per person rare ideas which appeared in one group than the unstructured groups (mean=0.23). There is a significant (p=.0434) interaction effect between the structure and the group size that the Delphi small-sized groups (mean=0.44) and the unstructured medium-sized groups (mean=0.29) produced disproportionately more per person rare ideas than the unstructured small-sized groups (mean=0.17) and the Delphi medium-sized groups (mean=0.30). However, there was no significant (p=.9176) difference on this measure between the small-sized (mean=0.30) and the medium-sized groups (mean=0.30).

Table 6.33 Means/ Standard Deviations of Number of Per Person Rare Ideas Appearing in One Group

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(0.44, 0.32)	(0.30, 0.18)	(0.37, 0.26)
Unstructured	(0.17, 0.13)	(0.29, 0.10)	(0.23, 0.13)
Total	(0.30, 0.28)	(0.30, 0.14)	(0.30, 0.22)

Table 6.34 ANOVA of Number of Per Person Rare Ideas Appearing in One Group

Source	(F, df)	Pr>F
Structure	(5.04, 1)*	.0304
Group Size	(0.01, 1)	.9176
Structure*Group Size	(4.35, 1)*	.0434

Table 6.35 presents the means and the standard deviations of the transformed form (a square root) of the number of per person rare ideas which appeared in one or two groups. The results of ANOVA for this measure shown as Table 6.36 suggest that the Delphi groups (mean=0.67) produced significantly (p=.0183) more per person rare ideas which appeared in one or two groups than the unstructured groups (mean=0.54). There is

a significant (p=.0464) interaction effect between the structure and the group size that the Delphi small-sized groups (mean=0.73) and the unstructured medium-sized groups (mean=0.58) produced disproportionately more per person rare ideas than the unstructured small-sized groups (mean=0.49) and the Delphi medium-sized groups (mean=0.60). However, there was no significant (p=.7275) difference on this measure between the small-sized (mean=0.61) and the medium-sized groups (mean=0.59).

Table 6.35 Means/ Standard Deviations of SQRT (Number of Per Person Rare Ideas Appearing in One or Two Groups)

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(0.73, 0.21)	(0.60, 0.18)	(0.67, 0.20)
Unstructured	(0.49, 0.20)	(0.58, 0.10)	(0.54, 0.16)
Total	(0.61, 0.23)	(0.59, 0.14)	(0.60, 0.19)

Table 6.36 ANOVA of SQRT (Number of Per Person Rare Ideas Appearing in One or Two Groups)

Source	(F, df)	Pr>F
Structure	(6.05, 1)*	.0183
Group Size	(0.12, 1)	.7275
Structure*Group Size	(4.23, 1)*	.0464

Table 6.37 presents the means and the standard deviations of the transformed form (a square root) of the number of per person rare ideas which appeared in one, two, or three groups. The results of ANOVA for this measure shown as Table 6.38 suggest that the Delphi groups (mean=0.70) produced significantly (p=.0076) more per person rare ideas which appeared in one or two groups than the unstructured groups (mean=0.55). There is a significant (p=.0456) interaction effect between the structure and the group size that the Delphi small-sized groups (mean=0.76) and the unstructured medium-sized groups (mean=0.60) produced disproportionately more per person rare ideas than the unstructured small-sized groups (mean=0.50) and the Delphi medium-sized groups

(mean=0.64). However, there was no significant (p=.8253) difference on this measure between the small-sized (mean=0.63) and the medium-sized groups (mean=0.62).

Table 6.37 Means/ Standard Deviations of SQRT (Number of Per Person Rare Ideas Appearing in One, Two, or Three Groups)

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(0.76, 0.20)	(0.64, 0.18)	(0.70, 0.20)
Unstructured	(0.50, 0.20)	(0.60, 0.10)	(0.55, 0.16)
Total	(0.63, 0.24)	(0.62, 0.14)	(0.63, 0.19)

Table 6.38 ANOVA of SQRT (Number of Per Person Rare Ideas Appearing in One, Two, or Three Groups)

Source	(F, df)	Pr>F
Structure	(7.89, 1)**	.0076
Group Size	(0.05, 1)	.8253
Structure*Group Size	(4.26, 1)*	.0456

From the above findings,

H16a. The Delphi groups will produce more ***per person rare ideas*** *than the unstructured asynchronous groups.*
Supported

H16b. The small-sized groups will produce more per person rare ideas than the medium-sized groups.
Not Supported

H16c. Communication structure interacts with group size so that the medium-sized Delphi groups produce disproportionately more per person rare ideas than the small-sized Delphi groups.
Opposite Direction Supported

6.1.2.4 Importance of Ideas. For the ratings on the importance of ideas, the correlations among the three faculty judges (Judge 1, 2 and 3) were higher (0.36 – 0.37) than the correlations among the all judges including the other two Ph.D. student judges (Judge 4 and 5) (0.03 – 0.24). Therefore separate measures were used for the three faculty judges and for all of the five judges.

Table 6.39 presents the means and the standard deviations of the average ratings of the importance of the ideas by the five judges—three faculty members and two Ph.D. student judges. For this measure, higher scores denote higher importance. The results of ANOVA are shown in Table 6.40. For the measure "Importance by All Judges" which is the average ratings of the importance by the five judges, the ANOVA results show no significant differences on the importance of ideas between Delphi and unstructured groups (p=.7940) or between small-sized and medium-sized groups (p=0.9366). No significant interaction effect was found (p=0.4305).

Table 6.39 Means/ Standard Deviations of Importance by All Judges

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(4.28, 0.23)	(4.34, 0.17)	(4.31, 0.20)
Unstructured	(4.32, 0.33)	(4.27, 0.18)	(4.29, 0.26)
Total	(4.30, 0.28)	(4.30, 0.18)	(4.30, 0.23)

Table 6.40 ANOVA of Importance by All Judges

Source	(F, df)	Pr > F
Structure	(0.07, 1)	.7940
Group Size	(0.01, 1)	.9366
Structure*Group Size	(0.63, 1)	.4305

Table 6.41 presents the means and standard deviations of the average ratings of importance by the three faculty judges who had relatively more correlated each other in their ratings (=Importance by Faculty Judges). For this measure, higher scores denote higher importance. Table 6.42 shows the results of ANOVA for this measure. The faculty judges' ratings also showed no significant differences on the importance of ideas between Delphi and unstructured groups (p=.7347) or between small-sized and medium-sized groups (p=0.9453). No significant interaction effect was found (p=0.1959).

Table 6.41 Means/ Standard Deviations of Importance by Faculty Judges

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(3.77, 0.31)	(3.89, 0.20)	(3.83, 0.26)
Unstructured	(3.86, 0.45)	(3.73, 0.28)	(3.80, 0.37)
Total	(3.82, 0.38)	(3.81, 0.25)	(3.81, 0.32)

Table 6.42 ANOVA of Importance by Faculty Judges

Source	(F, df)	Pr > F
Structure	(0.12, 1)	.7347
Group Size	(0.00, 1)	.9453
Structure*Group Size	(1.73, 1)	.1959

Based on the above findings,

H14a. The Delphi groups will produce ideas of higher ***importance*** *than the unstructured asynchronous groups.*
Not Supported

H14b. The medium-sized groups will produce ideas of higher importance than the small-sized groups.
Not Supported

H14c. Communication structure interacts with group size so that the medium-sized Delphi groups will produce ideas of disproportionately higher importance than the small-sized Delphi groups.
Not Supported

6.1.2.5 Creativity of Ideas. The five judges—three faculty members and two Ph.D. student judges—evaluated each unique idea in terms of its creativity. Since the correlations among the three faculty judges (Judge 1, 2 and 3) were higher (0.35 – 0.40) than the correlations among the all judges including the other two Ph.D. student judges (Judge 4 and 5) (0.09 – 0.30), separate measures were used for the three faculty judges and for all of the five judges.

Table 6.43 presents the means and the standard deviations of the measure "Creativity by All Judges" which is the average ratings of the creativity by the five judges. For this measure, higher scores denote lower creativity. Table 6.44 shows the results of ANOVA for this measure. The results show that there was no significant differences on the importance of ideas between Delphi and unstructured groups (p=.5380) or between small-sized and medium-sized groups (p=0.5537). No interaction between the structure and the group size was found (p=0.1018).

Table 6.43 Means/ Standard Deviations of Creativity by All Judges

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(3.48, 0.28)	(3.29, 0.12)	(3.38, 0.23)
Unstructured	(3,29, 0.39)	(3.38, 0.25)	(3.33, 0.33)
Total	(3.38, 0.35)	(3.33, 0.20)	(3.36, 0.28)

Table 6.44 ANOVA of Creativity by All Judges

Source	(F, df)	Pr > F
Structure	(0.39, 1)	.5380
Group Size	(0.36, 1)	.5537
Structure*Group Size	(2.80, 1)	.1018

Kolmogorov-Smirnov D for the average ratings for the creativity by the three faculty judges (=Creativity by Faculty Judges) showed that this measure failed to apply with the normal distribution assumption for parametric statistics. Therefore a transformation was done into a square root (See 5.2.3 for details). Table 6.45 shows the means and the standard deviations of the transformed form of this measure (i.e. the square root) which fits the normal distribution. Higher values for this measure denote higher creativity. Table 6.46 shows the results of the ANOVA for this measure. These results show no significant differences on the creativity of ideas between Delphi and unstructured groups (p=0.6386) or between small-sized and medium-sized groups (p=0.4259). There was no interaction effect found between the structure and the group size (p=.6993).

Table 6.45 Means/ Standard Deviations of SQRT (Creativity by Faculty Judges)

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(1.83, 0.06)	(1,80, 0.10)	(1.82, 0.08)
Unstructured	(1.81, 0.17)	(1.79, 0.07)	(1.80, 0.12)
Total	(1.82, 0.12)	(1.80, 0.08)	(1.81, 0.10)

Table 6.46 ANOVA of SQRT (Creativity by Faculty Judges)

Source	(F, df)	Pr > F
Structure	(0.22, 1)	.6386
Group Size	(0.65, 1)	.4259
Structure*Group Size	(0.15, 1)	.6993

Based on the above findings,

H17a. The Delphi groups will produce ideas of higher ***creativity*** *than the unstructured asynchronous groups.*
Not Supported

H17b. The medium-sized groups will produce ideas of higher creativity than the small-sized groups.
Not Supported

H17c. Communication structure interacts with group size so that the medium-sized Delphi groups will produce ideas of disproportionately higher creativity than the small-sized Delphi groups
Not Supported

6.1.2.6 Quality of Group Report. The quality of the group report was evaluated by the average of the two measures, the content (Content Quality) and the presentation (Presentation Quality) quality of the report. Each measure was evaluated by the average ratings of the four Ph.D. student judges. Table 6.47 presents the means and the standard deviations of Report Content. For this measure, higher scores denote higher quality. Table 6.48 shows the result of ANOVA for Content Quality and no significant difference was found either on the structure dimension (p=0.9018) or on the group size dimension (p=0.2753). No significant interaction effect was found (p=0.7367).

Table 6.47 Means/ Standard Deviations of Content Quality

(Mean, SD)	Small	Medium	Total
Delphi	(3.75, 1.11)	(4.24, 1.05)	(4.00, 1.08)
Non-Delphi	(3.83, 1.22)	(4.08, 1.06)	(3.95, 1.12)
Total	(3.79, 1.14)	(4.16, 1.04)	(3.98, 1.09)

Table 6.48 ANOVA of Report Content Quality

Source	(F, df)	P > F
Process	(0.02, 1)	.9018
Group Size	(1.22, 1)	.2753
Process*Group Size	(0.11, 1)	.7367

Table 6.49 shows the means and the standard deviations of Presentation Quality. For this measure, higher scores denote higher quality. Table 6.50 presents the result of ANOVA for this measure. The results suggest that in terms of Presentation Quality, no significant differences were found either on the structure dimension (p=0.3170) or on the group size dimension (p=0.3785). No significant interaction effect was found (p=0.6475).

Table 6.49 Means/ Standard Deviations of Presentation Quality

(Mean, SD)	Small	Medium	Total
Delphi	(3.72, 1.27)	(4.22, 1.18)	(3.97, 1.22)
Non-Delphi	(3.51, 1.40)	(3.67, 1.03)	(3.59, 1.20)
Total	(3.61, 1.31)	(3.94, 1.11)	(13.86, 5.70)

Table 6.50 ANOVA of Presentation Quality

Source	(F, df)	P > F
Process	(1.03, 1)	.3170
Group Size	(0.79, 1)	.3785
Process*Group Size	(0.21, 1)	.6475

The overall quality of the report (=Overall Group Report Quality) was calculated by the above two measures, Content Quality and Presentation Quality and this calculation was discussed in Sub-section 4.8.7.2. Table 6.51 presents the means and the standard deviations of Overall Group Report Quality. For this measure, higher scores denote higher quality. Table 6.52 shows that no significant difference was found either on the structure dimension (p=0.8588) or on the group size dimension (p=0.2916). No significant interaction effect was found (p=0.7437).

Table 6.51 Means/ Standard Deviations of Overall Group Report Quality

(Mean, SD)	Small	Medium	Total
Delphi	(3.93, 1.17)	(4.39, 0.96)	(4.16, 1.07)
Non-Delphi	(4.10, 1.14)	(4.34, 1.06)	(4.22, 1.08)
Total	(4.01, 1.13)	(4.37, 0.99)	(13.86, 5.70)

Table 6.52 ANOVA of Overall Group Report Quality

Source	(F, df)	P > F
Process	0.03	.8588
Group Size	1.14	.2916
Process*Group Size	0.11	.7437

The above findings led to the following conclusions on the quality of the group report;

H18a. The Delphi groups will produce better quality ***reports*** *than the unstructured asynchronous groups.*
Not Supported

H18b. The medium-sized groups will produce better reports of than the small-sized groups.
Not Supported

H18c. Communication structure interacts with group size so that the medium-sized Delphi groups will produce disproportionately better quality reports than the small-sized Delphi groups.
Not Supported

6.1.3 Satisfaction

6.1.3.1 Process Satisfaction. Table 6.53 shows the means and the standard deviations of process satisfaction. For this measure, higher scores denote higher satisfaction. The results of ANOVA in Table 6.54 suggest that there is no significant differences found either on the structure dimension (p=0.3934) or on the group size dimension (p=0.5491) in terms of process satisfaction.

Table 6.53 Means/ Standard Deviations of Process Satisfaction

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(18.83, 1.96)	(19.09, 1.78)	(18.96, 1.83)
Unstructured	(19.26, 3.37)	(19.80, 1.01)	(19.53, 2.45)
Total	(19.04, 2.70)	(19.45, 1.46)	(19.24, 2.16)

Table 6.54 ANOVA of Process Satisfaction

Source	(F, df)	Pr>F
Structure	(0.74, 1)	.3934
Group Size	(0.37, 1)	.5491
Structure*Group Size	(0.04, 1)	.8343

From the above findings,

H19a. The Delphi groups will have higher level of ***process satisfaction*** *than the unstructured asynchronous groups.*
Not Supported

H19c. Communication structure interacts with group size so that the medium-sized Delphi groups will have disproportionately higher level of process satisfaction than the small Delphi groups.
Not Supported

6.1.3.2 Cohesiveness. Table 6.55 presents the means and the standard deviations of the level of cohesiveness. For this measure, higher scores denote higher level of cohesiveness. The results of ANOVA in Table 6.56 shows no significant differences either between the Delphi groups and the unstructured condition (p=0.6126) or between the small-sized and the medium-sized groups (p=0.1853).

Table 6.55 Means/ Standard Deviations of Cohesiveness

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(7.42, 0.73)	(7.37, 0.95)	(7.40, 0.83)
Unstructured	(7.62, 1.28)	(6.85, 0.85)	(7.23, 1.13)
Total	(7.52, 1.02)	(7.11, 0.92)	(7.31, 0.98)

Table 6.56 ANOVA of Cohesiveness

Source	(F, df)	Pr>F
Structure	(0.26, 1)	.6126
Group Size	(1.82, 1)	.1853
Structure*Group Size	(1.38, 1)	.2474

The above findings conclude:

H21a. The Delphi groups will have lower level of ***cohesiveness*** *than the unstructured asynchronous groups.*
Not Supported

H21c. Communication structure interacts with group size so that the medium-sized Delphi groups will have disproportionately higher level of cohesiveness than the small Delphi groups.
Not Supported

6.2 Supplementary: Efficiency of Idea Production

6.2.1 Efficiency of Unique Idea Production

In Sub-section 4.10.5., the efficiency of unique idea production was defined as the measure for the relative productivity of the group in generating unique ideas compared to its general idea generation productivity. In specific,

Efficiency of Production for Unique Ideas = Number of Total Unique Ideas in Discussion / Number of Total Raw Ideas in Discussion

Table 6.57 presents the means and the standard deviations of Efficiency of Unique Idea Production which is the measure for the efficiency of the group in producing the unique ideas compared to its general productivity in generating the raw ideas. A higher value in this measure denotes the group was more efficient in producing the unique ideas considering its general productivity in generating the raw ideas. The results of ANOVA for this measure shown in Table 6.58 suggest that the Delphi groups and the unstructured groups are not significantly different (p=.2142) and the small-sized and the medium-sized groups are not significantly different (p=.1505) in terms of the efficiency of unique idea production.

Table 6.57 Means/ Standard Deviations of Efficiency of Unique Idea Production

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(0.89, 0.07)	(0.82, 0.13)	(0.85, 0.11)
Unstructured	(0.90, 0.12)	(0.88, 0.10)	(0.89, 0.10)
Total	(0.89, 0.09)	(0.85, 0.12)	(0.87, 0.11)

Table 6.58 ANOVA of Efficiency of Unique Idea Production

Source	(F, df)	Pr>F
Structure	(1.59, 1)	.2142
Group Size	(2.15, 1)	.1505
Structure*Group Size	(0.44, 1)	.5086

6.2.2 Efficiency of Rare Idea Production

In Sub-section 4.10.5., the efficiency of rare idea production was defined as the measure for the relative productivity of the group in generating rare ideas compared to its general idea generation productivity and it was measured at the three levels of the rarity. In specific,

Efficiency of Production for Rare Ideas appearing in One Group = Number of Total Rare Ideas appearing in One Group / Number of Total Raw Ideas in Discussion

Efficiency of Production for Rare Ideas appearing in One or Two Groups = Number of Total Rare Ideas appearing in One or Two Groups / Number of Total Raw Ideas in Discussion

Efficiency of Production for Rare Ideas appearing in One, Two, or Three Groups = Number of Total Rare Ideas appearing in One, Two, or Three Groups / Number of Total Raw Ideas in Discussion

Table 6.59 presents the means and the standard deviations of the efficiency of the group in producing the rare ideas which appeared in one group. Higher values on this measure suggest that the group is relatively more productive in generating rare ideas compared to its general idea generation productivity. The results of ANOVA shown as Table 6.60 suggest that there was no significant difference found between the Delphi groups and the unstructured groups (p=.9874) or between the small-sized and the medium-sized groups (p=.2498). However, a significant interaction effect was found between the structure and the group size (p=.0377). The Delphi small-sized groups (mean=0.17) and the unstructured medium-sized groups (mean=0.21) were more efficient in producing the rare ideas which appeared in One, Two, or three groups than the Delphi medium-sized groups (mean=0.15) and the unstructured small-sized groups (mean=0.11).

Table 6.59 Means/ Standard Deviations of Efficiency of Rare Idea Production (Rare Ideas appearing in One Group)

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(0.17, 0.12)	(0.15, 0.07)	(0.16, 0.09)
Unstructured	(0.11, 0.09)	(0.21, 0.10)	(0.16, 0.10)
Total	(0.14, 0.10)	(0.18, 0.09)	(0.16, 0.10)

Table 6.60 ANOVA of Efficiency of Rare Idea Production (Rare Ideas appearing in One Group)

Source	(F, df)	Pr>F
Structure	(0.00, 1)	.9874
Group Size	(1.36, 1)	.2498
Structure*Group Size	(4.62, 1)*	.0377

Table 6.61 presents the means and the standard deviations of the efficiency of the group in producing the rare ideas which appeared in one or two groups. Higher values on this measure suggest that the group is relatively more productive in generating rare ideas compared to its general idea generation productivity. The results of ANOVA shown as Table 6.62 suggest that there was no significant difference found between the Delphi groups and the unstructured groups (p=.9632) or between the small-sized and the medium-sized groups (p=.6797). The Delphi small-sized groups (mean=0.23) and the unstructured medium-sized groups (mean=0.24) appear more efficient in producing the rare ideas which appeared in one or two groups than the Delphi medium-sized groups (mean=0.19) and the unstructured small-sized groups (mean=0.17), but this interaction effects was not significant (p=.0593).

Table 6.61 Means/ Standard Deviations of Efficiency of Rare Idea Production (Rare Ideas appearing in One or Two Groups)

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(0.23, 0.10)	(0.19, 0.08)	(0.21, 0.09)
Unstructured	(0.17, 0.08)	(0.24, 0.11)	(0.21, 0.10)
Total	(0.20, 0.09)	(0.21, 0.10)	(0.21, 0.09)

Table 6.62 ANOVA of Efficiency of Rare Idea Production (Rare Ideas appearing in One or Two Groups)

Source	(F, df)	Pr>F
Structure	(0.00, 1)	0.9632
Group Size	(0.17, 1)	0.6797
Structure*Group Size	(3.77, 1)	0.0593

Table 6.63 presents the means and the standard deviations of the efficiency of the group in producing the rare ideas which appeared in One, Two, or three groups. Higher values on this measure suggest that the group is relatively more productive in generating rare ideas compared to its general idea generation productivity. The results of ANOVA shown as Table 6.64 suggest that there was no significant difference found between the Delphi groups and the unstructured groups (p=.7674) or between the small-sized and the medium-sized groups (p=.5549). The Delphi small-sized groups (mean=0.25) and the unstructured medium-sized groups (mean=0.26) were more efficient in producing the rare ideas which appeared in One, Two, or three groups than the Delphi medium-sized groups (mean=0.21) and the unstructured small-sized groups (mean=0.18), even though this interaction effects was not significant (p=.0614).

Table 6.63 Means/ Standard Deviations of Efficiency of Rare Idea Production (Rare Ideas appearing in One, Two, or Three Groups)

(Mean, SD)	Small-sized	Medium-sized	Total
Delphi	(0.25, 0.11)	(0.21, 0.09)	(0.23, 0.10)
Unstructured	(0.18, 0.08)	(0.26, 0.11)	(0.22, 0.10)
Total	(0.22, 0.10)	(0.23, 0.10)	(0.23, 0.10)

Table 6.64 ANOVA of Efficiency of Rare Idea Production (Rare Ideas appearing in One, Two, or Three Groups)

Source	(F, df)	Pr>F
Structure	(0.09, 1)	.7674
Group Size	(0.35, 1)	.5549
Structure*Group Size	(3.70, 1)	.0614

6.3 Correlation Analysis

To investigate the relations among the variables, especially between the intervening variables and dependent variables, Pearson R's were calculated. Table 6.65 presents the correlations between the number of ideas and the process gains / losses. A significant negative correlation (R=-0.30, p=.0497) found between perceived learning and the number of per person unique ideas in report. The equality of participation measured by the word count positively correlates to the number of total raw ideas (R=0.30, p=.0471) and to the number of total unique ideas in discussion (R=-0.32, p=.0351). These correlations suggest that the more equally the group members participated in the discussion, the more they produced total raw ideas and total unique ideas in discussion.

Table 6.66 presents the correlations between satisfaction and the number of ideas. Process satisfaction had significant negative correlations with the square root of the number of per person raw ideas (R=-0.31, p=.0429), the number of per person unique ideas in discussion (R=-0.33, p=.0294), the square root of the number of per person rare ideas appearing in one or two groups (R=-0.33, p=.0301) and the square root of the number of the number of per person rare ideas appearing in one, two, or three groups (R=-0.33, p=.0275). Cohesiveness had significant negative correlations with the square root of the number of per person raw ideas (R=-0.31, p=.0417) and the number of per person unique ideas in discussion (R=-0.35, p=.0187). Table 6.67 suggests that the total word count positively correlates to the number of the total raw ideas ($R=0.44$, $p=.0028$), the number of the total unique ideas in discussion ($R=0.37$, $p=.0135$), and the square root of the number of the total unique ideas in report ($R=0.32$, $p=.0314$).

Table 6.65 Correlations between Number of Ideas and Process Gains / Losses

Pearson R
(P level)

Process Gains / Losses vs. Number of Ideas	Total Raw Ideas	SQRT (Number of Per Person Raw Ideas)	Total Unique Ideas in Discussion	SQRT (Total Unique Ideas in Report)	Per Person Unique Ideas in Discussion	Per Person Unique Ideas in Report	Total Rare Ideas appearing in One Group	Total Rare Ideas appearing in One or Two Groups)	Total Rare Ideas appearing in One, Two, or Three Groups)	Per Person Rare Ideas appearing in One Group	SQRT (Per Person Rare Ideas appearing in One or Two Groups)	SQRT (Per Person Rare Ideas appearing in One, Two, or Three Groups)
Synergy	-0.04 (.8133)	-0.11 (.4675)	-0.12 (.4361)	-0.14 (.3036)	-0.23 (.1340)	-0.22 (.1586)	-0.09 (.5713)	-0.13 (.4149)	-0.10 (.5200)	-0.12 (.4445)	-0.18 (.2358)	-0.16 (.3030)
Learning	-0.04 (.8173)	-0.14 (.3432)	-0.11 (.4595)	-0.21 (.1808)	-0.25 (.1041)	**-0.30 (.0497)***	-0.08 (.5870)	-0.14 (.3596)	-0.12 (.4212)	-0.15 (.3293)	-0.24 (.1233)	-0.21 (.1791)
Inequality by Word Count	**-0.30 (.0471)***	-0.12 (.4254)	**-0.32 (.0351)***	-0.22 (.1431)	-0.12 (0.4271)	-0.02 (.8766)	-0.21 (.1635)	-0.18 (.2395)	-0.22 (.1496)	-0.11 (.4765)	-0.12 (.4478)	-0.16 (.2926)
SQRT (Inequality by Ideas)	-0.04 (.7854)	0.15 (.3245)	0.005 (.9729)	0.10 (.5068)	0.19 (.2061)	0.26 (.0913)	-0.05 (.7471)	-0.05 (.7695)	0.002 (.9882)	0.07 (0.6733)	0.06 (.6803)	0.13 (.3825)

Table 6.66 Correlations between Number of Ideas and Satisfaction

Pearson R
(P level)

Satisfaction vs. Number of Ideas	Total Raw Ideas	SQRT (Number of Per Person Raw Ideas)	Total Unique Ideas in Discussion	SQRT (Total Unique Ideas in Report)	Per Person Unique Ideas in Discussion	Per Person Unique Ideas in Report	Total Rare Ideas appearing in One Group	Total Rare Ideas appearing in One or Two Groups)	Total Rare Ideas appearing in One, Two, or Three Groups)	Per Person Rare Ideas appearing in One Group	SQRT (Per Person Rare Ideas appearing in One or Two Groups)	SQRT (Per Person Rare Ideas appearing in One, Two, or Three Groups)
Process Satisfaction	-0.12 (.4430)	**-0.31 (.0429)***	-0.14 (.3611)	-0.03 (.8519)	**-0.33 (.0294)***	-0.13 (.3843)	-0.17 (.2684)	-0.20 (.1918)	-0.19 (.2245)	-0.27 (.0750)	**-0.33 (.0301)***	**-0.33 (.0275)***
Cohesiveness	-0.07 (.6397)	**-0.31 (.0417)***	-0.12 (.4328)	-0.10 (.5353)	**-0.35 (.0187)***	-0.27 (.0817)	0.02 (.8802)	-0.06 (.6768)	-0.05 (.7522)	-0.07 (.6594)	-0.17 (.2757)	-0.16 (.3040)

Table 6.67 Correlations between Number of Ideas and Word Count

Pearson R
(P level)

Participation vs. Number of Ideas	Total Raw Ideas	SQRT (Number of Per Person Raw Ideas)	Total Unique Ideas in Discussion	SQRT (Total Unique Ideas in Report)	Per Person Unique Ideas in Discussion	Per Person Unique Ideas in Report	Total Rare Ideas appearing in One Group	Total Rare Ideas appearing in One or Two Groups)	Total Rare Ideas appearing in One, Two, or Three Groups)	Per Person Rare Ideas appearing in One Group	SQRT (Per Person Rare Ideas appearing in One or Two Groups)	SQRT (Per Person Rare Ideas appearing in One, Two, or Three Groups)
Total Word Count	**0.44 (.0028)****	-0.04 (.8071)	**0.37 (.0135)***	**0.32 (.0314)***	-0.12 (.4324)	-0.10 (. 5112)	**0.32 (.0346)***	**0.35 (.0189)***	**0.37 (.0127)***	0.07 (.6413)	0.07 (.6361)	0.09 (.5563)
Per Person Word Count	0.01 (.9638)	0.21 (.1704)	-0.03 (.8340)	-0.03 (.8236)	0.16 (.2938)	0.14 (.3560)	0.05 (.7680)	0.10 (.5137)	0.11 (.4849)	0.18 (.2304)	0.20 (.1991)	0.20 (.1839)
SQRT (Coordinator Word Count)	0.11 (.4601)	-0.07 (.6557)	0.10 (.5129)	0.15 (.3191)	-0.08 (.6038)	0.04 (.8148)	0.28 (.0644)	0.27 (.0713)	0.25 (.0993)	0.15 (.3304)	0.06 (.7025)	0.04 (.8076)

Tables 6.68 and 6.69 show that the square root of the creativity of ideas by faculty judges positively correlates to perceived learning (R=0.35, p=.0205) and to cohesiveness (R=0.43, p=.0035).Table 6.70 shows correlations between the word count and the quality of ideas / report. The total word count positively correlates to the quality of report content (R=0.42, p=.0041), to the quality of report presentation (R=0.39, p=.0082), and to the overall group report quality (R=0.41, p=.0064). The per person word count positively correlates to the quality of report content (R=0.37, p=.0144), to the quality of report presentation (R=0.36, p=.0173), and to the overall group report quality (R=0.35, p=.0207). The square root of the coordinator word count positively correlates to the quality of report content (R=0.37, p=.0131) and to the overall group report quality (R=0.39, p=.0081).

Table 6.68 Correlations between Idea / Report Quality and Process Gains / Losses

Pearson R
(P level)

Process vs. Quality of Ideas / Reports	Importance of Ideas by All Judges	Importance of Ideas by Faculty Judges	Creativity of Ideas by All Judges	SQRT (Creativity of Ideas by Faculty Judges)	Report Content	Report Presentation	Report Overall Quality
Synergy	0.16 (.2958)	0.05 (.7594)	0.12 (.4387)	0.24 (.1116)	0.09 (.5602)	0.11 (.4694)	0.04 (.8174)
Learning	0.21 (.1803)	0.23 (.1351)	0.09 (.5577)	**0.35 (.0205)***	0.08 (.6076)	0.13 (.4141)	0.04 (.8033)
Inequality by Word Count	0.05 (.7715)	0.04 (.8060)	-0.17 (.2735)	-0.25 (.0992)	0.16 (.2848)	0.04 (.8065)	0.21 (.1663)
SQRT(Inequality by Raw Ideas)	-0.23 (.1411)	-0.11 (.4648)	-0.25 (.1013)	0.06 (.6887)	0.01 (.9274)	-0.13 (.4058)	0.08 (.6025)

Table 6.69 Correlations between Idea / Report Quality and Satisfaction

Pearson R
(P level)

Satisfaction vs. Quality of Ideas / Reports	Importance of Ideas by All Judges	Importance of Ideas by Faculty Judges	Creativity of Ideas by All Judges	SQRT (Creativity of Ideas by Faculty Judges)	Report Content	Report Presentation	Report Overall Quality
Process Satisfaction	0.25 (.1044)	0.28 (.0656)	0.15 (.3455)	0.29 (.0593)	0.15 (.3473)	0.15 (.3314)	0.12 (.4429)
Cohesiveness	0.15 (.3363)	0.13 (.3910)	0.15 (.3385)	**0.43 (.0035)****	0.14 (.3501)	0.14 (3721)	0.12 (.4326)

Table 6.70 Correlations between Idea / Report Quality and Word Count

Pearson R
(P level)

Process vs. Quality of Ideas / Reports	Importance of Ideas by All Judges	Importance of Ideas by Faculty Judges	Creativity of Ideas by All Judges	SQRT (Creativity of Ideas by Faculty Judges)	Report Content	Report Presentation	Report Overall Quality
Total Word Count	-0.03 (.8306)	-0.05 (.7245)	0.05 (7474)	0.06 (.7011)	**0.42 (.0041)****	**0.39 (.0082)****	**0.41 (.0064)****
Per Person Word Count	0.00059 (.9970)	0.00007 (.9997)	0.15 (.3219)	0.16 (.2997)	**0.37 (.0144)***	**0.36 (.0173)***	**0.35 (.0207)***
SQRT (Coordinator Word Count)	-0.04 (.7732)	-0.05 (.7584)	0.07 (.6734)	0.02 (.8938)	**0.37 (.0131)***	0.26 (.0823)	**0.39 (0081)****

Table 6.71 indicates that perceived intellectual synergy positively correlates to perceived learning ($R=0.59$, $p<.0001$), to process satisfaction ($R=0.53$, $p=.0002$) and to cohesiveness ($R=0.67$, $p<.0001$). Perceived learning positively correlates to process satisfaction ($R=0.38$, $p=.0103$) and to cohesiveness ($R=0.49$, $p=.0007$). Process satisfaction had a positive correlation with cohesiveness ($R=0.71$, $p<.0001$). The group perceived higher intellectual synergy when the group members participated in the discussion more ($R=0.33$, $p=.0290$ for the total word count; $R=0.37$, $p=.0142$ for the per person word count). The group perceived higher cohesiveness when the group members participated in the discussion more ($R=0.35$, $p=.0203$ for the total word count). The strong negative correlations ($R=-0.55$, $p=.0001$) between the square root of the coordinator word count and the equality of participation by word count was expected because as the group coordinator dominate the discussion the higher inequality of participation the group tends to have.

Table 6.71 Other Significant Correlations

Pearson R
(P level)

Variable 1	Variable 2	Pearson R (P level)
Intellectual synergy	Learning	**0.59 (<.0001)*****
	Process Satisfaction	**0.53 (.0002)*****
	Cohesiveness	**0.67 (<.0001)*****
Learning	Process Satisfaction	**0.38 (.0103)***
	Cohesiveness	**0.49 (.0007)*****
Process Satisfaction	Cohesiveness	**0.71 (<.0001)*****
Inequality of Participation by Word Count	SQRT (Inequality of Participation by Raw Ideas)	0.24 (.1101)
Inequality of Participation by Word Count	Cohesiveness	-0.28 (.0671)
Total Word Count	Intellectual Synergy	**0.33 (0.0290)***
	Cohesiveness	**0.35 (0.0203)***
Per Person Word Count	Intellectual Synergy	**0.37 (.0142)***
SQRT (Coordinator Word Count)	Inequality of Participation by Word Count	**0.55 (.0001)*****

It is worth checking the correlations by condition to see whether the significance occurred in a certain experimental condition. Table 6.72 shows the correlations between the square root of the coordinator word counts and the number of ideas in the Delphi and the unstructured conditions. In the Delphi condition, the coordinator word counts positively correlates to the total number of unique ideas in discussion (R=0.44635, p=.0373), the square root of the total unique ideas in report (R=0.49891, p=.0181), and the per person unique ideas in report (R=0.49933, p=.0180). However, no significant correlations were found in the unstructured condition.

Table 6.72 Correlations between SQRT (Coordinator Word Count) and Number of Ideas for Delphi and Unstructured Conditions

Pearson R (P level)

		Total Raw Ideas	SQRT (Number of Per Person Raw Ideas)	Total Unique Ideas in Discussion	SQRT (Total Unique Ideas in Report)	Per Person Unique Ideas in Discussion	Per Person Unique Ideas in Report
SQRT(Coordinator Word Count)	**Delphi**	0.38445 (.0773)	0.39102 (.0720)	0.44635 (.0373)*	0.49891 (.0181)*	0.39064 (.0723)	0.49933 (.0180)*
	Unstructured	0.12867 (.5682)	-0.12571 (.5772)	0.02221 (.9218)	0.11631 (.6062)	-0.26094 (.2408)	-0.08680 (.7009)

Table 6.73 shows the correlations between the square root of the coordinator word counts and the total word count in the Delphi and the unstructured conditions. In the unstructured condition, the coordinator word counts positively correlates to the total word count (R=0.66522, p=.0007), while this correlation is not found in the Delphi condition (R=0.35834, p=.1015).

Table 6.73 Correlations between SQRT (Coordinator Word Count) and Total Word Count for Delphi and Unstructured Conditions

Pearson R (P level)

		Total Word Count
SQRT(Coordinator Word Count)	**Delphi**	0.35834 (.1015)
	Unstructured	0.66522 (.0007)***

Table 6.74 shows the correlations between the square root of the coordinator word counts and the total word count in the Delphi and the unstructured conditions. In the unstructured condition, the coordinator word counts positively correlates to the total word count (R=0.66522, p=.0007), while this correlation is not found in the Delphi condition (R=0.35834, p=.1015).

Table 6.74 Correlations between Participation Measures and Report Quality for Delphi and Unstructured Conditions

Person R (P level)

		Report Content	**Report Presentation**	**Report Overall Quality**
Total Word Count	**Delphi**	0.56052 (.0067)***	0.56870 (.0057)***	0.56123 (.0066)***
	Unstructured	0.34274 (.1184)	0.30161 (.1725)	0.29066 (.1894)
Per Person Word Count	**Delphi**	0.37735 (.0834)	0.37593 (.0847)	0.40626 (.0606)
	Unstructured	0.35575 (.1042)	0.34062 (.1208)	0.29066 (.1894)
SQRT (Coordinator Word Count)	**Delphi**	0.37039 (.0897)	0.29954 (.1756)	0.37845 (.0824)
	Unstructured	0.40211 (.0636)	0.32629 (.1383)	0.42042 (.0514)

Table 6.75 shows that in the Delphi condition, the perceived learning positively correlates to perceived intellectual synergy (R=0.80248, p<.0001), while no correlation was found in the unstructured condition.

Table 6.75 Correlations between Perceived Learning and Perceived Intellectual Synergy for Delphi and Unstructured Conditions

Person R (P level)

		Perceived Intellectual Synergy
Perceived Learning	**Delphi**	**0.80248 (<.0001)****
	Unstructured	0.36777 (.0922)

Table 6.76 shows that in the Delphi condition, the inequality of participation by word count positively correlates to the square root of the per person number of rare ideas appearing in one or two groups (R=0.42404, p=.0492). However in the unstructured condition, the inequality of participation by word count negatively correlates to the total number of rare ideas appearing in one group (R=-0.45110, p=.0351) and to the per person

number of rare ideas appearing in one group (R=-0.43914, p=.0409). Table 6.75 also shows that in the Delphi condition, process satisfaction negatively correlates to the total and per person number rare ideas (with the exception of the total number of rare ideas appearing in one, two or three groups), while this correlations are not found in the unstructured condition.

Table 6.76 Correlations between Inequality of Participation / Process Satisfaction and Number of Rare Ideas for Delphi and Unstructured Conditions

Person R
(P level)

		Total Rare Ideas appearing in One Group	Total Rare Ideas appearing in One or Two Groups)	Total Rare Ideas appearing in One, Two, or Three Groups)	Per Person Rare Ideas appearing in One Group	SQRT (Per Person Rare Ideas appearing in One or Two Groups)	SQRT (Per Person Rare Ideas appearing in One, Two, or Three Groups)
Inequality of Participation by Word Count	**Delphi**	0.26699 (.2297)	0.23210 (.2986)	0.21468 (.3373)	0.42132 (.0508)	**0.42404 (.0492)***	0.38550 (.0764)
	Unstructured	**-0.45110 (.0351)***	-0.33446 (.1282)	-0.38117 (.0801)	**-0.43914 (.0409)***	-0.22184 (.3211)	-0.28793 (.1938)
Process Satisfaction	**Delphi**	**-0.45603 (.0329)***	**-0.43647 (.0423)***	-0.37663 (.0840)	**-0.48532 (.0220)***	**-0.49163 (.0201)***	**-0.46693 (.0285)***
	Unstructured	0.13983 (.5349)	0.08131 (.7191)	0.05888 (.7946)	0.05138 (.8204)	-0.09812 (.6640)	-0.17783 (.4285)

In sum, the following general pattern model of correlations was constructed from the above findings. Among the process gains / losses, perceived intellectual synergy and the perceived learning are negative mediators to the quantity of ideas. On the contrary, the level of participation was a positive mediator which increases the quantity of the ideas. The equality of participation is a positive mediator to the total number of raw ideas and the total number of unique ideas in discussion. The quantity of ideas, especially the per person ideas, is a negative mediators to process satisfaction and cohesiveness. This tendency was especially significant for process satisfaction of Delphi groups toward the quantity of rare ideas produced: in Delphi condition, the more members produced rare ideas the less they were satisfied with the process. However, this negative correlation between the number of rare ideas and process satisfaction was not found in the unstructured condition. No strong mediators that explain the quality of ideas were found. The quality of the report positively correlates to the word counts of the members in the Delphi condition, but no significant correlation between the quality of report and the total word count found in the unstructured condition. In the Delphi condition, the more words the group coordinator say the more unique ideas the group produced in discussion and report. However, this positive correlation between the word count of the group coordinator and the number of unique ideas is not found in the unstructured condition. Instead, in the unstructured condition, the group coordinator word count was positively related to the group members' total word count; i.e. the more group coordinator participated in discussion the more the group members also participated in discussion. But there is no correlation between the group coordinator's word count and the members' word counts in the Delphi condition.

6.4 Conclusions

The results of the test for the hypotheses suggest that Delphi structure is effective in producing more ideas in asynchronous meetings. In asynchronous group communication environments, the groups facilitated by Delphi structure produced significantly more total unique ideas and more total rare ideas than unstructured groups having no facilitation supports. Delphi groups were also superior to unstructured groups in terms of the number of per person ideas. The evaluation of the quality / creativity of ideas and quality of report found no significant difference between these two conditions. There was no difference found between the Delphi and the unstructured groups in terms of process satisfaction and cohesiveness.

For the dimension of the group size, the medium-sized groups produced significantly more total (raw, unique and rare) ideas than the small-sized groups. However, in terms of the number of per person ideas, the small-sized groups were superior to the medium-sized groups. (This effect was significant on the per person unique ideas in discussion and close to $p=.05$ significance on the per person raw ideas and the per person unique ideas in report.) Opposite to the prediction, the members of the medium-sized groups participated in discussion more equally than the members of the small-sized groups. The evaluation of the quality / creativity of ideas and quality of report found no significant differences between the small-sized groups and the medium-sized groups. There was no difference on process satisfaction and cohesiveness between the small-sized groups and the medium-sized groups.

The (in)equality of participation was the only process gain / loss that significantly differs between the conditions. The members of Delphi groups participated in discussion more equally than unstructured groups and the members of small-sized groups participated more equally in discussion than the members of the medium-sized groups. There were significant positive correlations between the equality of participation and the total number of raw ideas or the total number of unique ideas in discussion.

Significant interaction effects were found on the number of per person rare ideas between the structure and the group size; the Delphi small-sized groups produced significantly more per person rare ideas than the unstructured small-sized groups and the unstructured medium-sized groups produced significantly more per person rare ideas than the unstructured small-sized groups. This interaction effects was also found in terms of the efficiency of rare idea production; in producing rare ideas, the Delphi small-sized groups were significantly more efficient than the unstructured small-sized groups and the unstructured medium-sized groups were significantly more efficient than the unstructured small-sized groups.

It was surprising that perceived intellectual synergy, perceived learning, process satisfaction and cohesiveness negatively correlated to the quantity of ideas the group produced. This tendency is especially significant for Delphi groups' satisfaction toward the quantity of rare idea produced. In the Delphi condition, the more the group discussed the issue the better the quality of the report produced, but no significant correlation between the process satisfaction and the number of rare ideas was found in the unstructured condition. In the unstructured condition, the more the group coordinator participated in discussion, the better the quality of the report the group produced.

However, no significant correlation between the coordinator word count and the quality of report was found in the Delphi condition. In general, there is significant correlations between the process gains / losses and the satisfaction measures.

CHAPTER 7

DISCUSSION AND LIMITATIONS

The objective of this chapter is to summarize the results of the study and to discuss the significance and limitations of the study. Section 7.1 provides a summary table of the results of the study and discusses the significance of those results.

7.1 Discussion

Table 7.1 shows the summary of the ANOVA results of this study.

Table 7.1 Summary of ANOVA Results

Measure		**Direction (Means)**	**P value**	**Hypothesis**	**Conclusion**
Group Process / Losses					
Intellectual Synergy			.9776	H1a. D > U	Not Supported
			.6621	H1b. M > S	Not Supported
			.5520	H1c. DM >> DS	Not Supported
Learning			.6294	H3a. D > U	Not Supported
			.7685	H3b. M > S	Not Supported
			.8038	H3c. DM >> DS	Not Supported
Participation	Total Word Count		.7107	H4a. D > U	Not Supported
		$M > S^{***}$	**<.0001**	**H4b. $M > S^{***}$**	**Supported**
	Per Person Word Count		.8958	H7a. D > U	Not Supported
			.3843	H7b. S > M	Not Supported
	SQRT (Coordinator Word Count)		.1581	H8a. D > U	Not Supported
			.3268	H8b. M > S	Not Supported
			.4613	H8c. UM >> US	Not Supported
Inequality of Participation	by Word Count	**$U > D^{**}$**	**.0074**	**H9a. $U > D^{**}$**	**Supported**
		$S > M^{*}$	**.0346**	H9b. M > S	**Opposite Direction Supported**
			.3301	H9c. DS >> DM	Not Supported
	SQRT(by Number of Raw Ideas)		.7372	H9a. D > U	Not Supported
			.1109	H9b. M > S	Not Supported
			.1332	H9c. DS >> DM	Not Supported

Table 7.1 Summary of ANOVA Results (Continued)

Measure		Direction (Means)	P value	Hypothesis	Conclusion
Quantity of Ideas					
Raw Ideas	Total	**$D > U^{***}$**	**<.0001**	**H10a. $D > U^{***}$**	**Supported**
		$M > S^{***}$	**<.0001**	**H10b. $M > S^{***}$**	**Supported**
			.9399	H10c. DM >> DS	Not Supported
	Per Person	**$D > U^{***}$**	**<.0001**	**H12a. $D > U^{***}$**	**Supported**
		S > M	.0789	H12b. S > M	Not Supported
			.1461	H12c. DM >> DS	Not Supported
Unique Ideas	Total in Discussion	**$D > U^{**}$**	**.002**	**H11a. $D > U^{**}$**	**Supported**
		$M > S^{***}$	**<.0001**	**H11b. $M > S^{***}$**	**Supported**
			.7145	H11c. DM >> DS	Not Supported
	SQRT (Total in Report)	**$D > U^{**}$**	**.0042**	**H11a. $D > U^{**}$**	**Supported**
		$M > S^{***}$	**.0001**	**H11b. $M > S^{***}$**	**Supported**
			.6956	H11c. DM >> DS	Not Supported
	Per Person in Discussion	**$D > U^{***}$**	**<.0001**	**H13a. $D > U^{***}$**	**Supported**
		$S > M^{*}$	**.0249**	**H13b. $S > M^{*}$**	**Supported**
		DS >> DM	.0948	H13c. DM >> DS	Opposite Direction Partially Supported
	Per Person in Report	**$D > U^{**}$**	**.0015**	**H13a. $D > U^{**}$**	**Supported**
		S > M	.0773	H13b. S > M	Partially Supported
			.2923	H13c. DM >> DS	Not Supported

Table 7.1 Summary of ANOVA Results (Continued)

Measure			Direction (Means)	P value	Hypothesis	Conclusion
Rare Ideas	Total	appearing in One Group	D > U	.0973	H15a. D > U	Partially Supported
			$M > S^{***}$	**.0009**	**H15b. $M > S^{***}$**	**Supported**
				.1391	H15c. DM >> DS	Not Supported
		appearing in One or Two Groups	**$D > U^{*}$**	**.0409**	**H15a. $D > U^{*}$**	**Supported**
			$M > S^{**}$	**.0013**	**H15b. $M > S^{**}$**	**Supported**
				.2437	H15c. DS << DM	Not Supported
		appearing in One, Two, or Three Groups	**$D > U^{*}$**	**.0180**	**H15a. $D > U^{*}$**	**Supported**
			$M > S^{***}$	**.0005**	**H15b. $M > S^{***}$**	**Supported**
				.2916	H15c. DM >> DS	Not Supported
	Per Person	appearing in One Group	**$D > U^{*}$**	**.0304**	**H16a. $D > U^{*}$**	**Supported**
				.9176	H16b. S > M	Not Supported
			DS > DM, $UM > US^{*}$	**.0434**	H16c. DM >> DS	**Opposite Direction Supported**
		appearing in One or Two Groups	D > U	**.0183**	**H16a. $D > U^{*}$**	**Supported**
				.7257	H16b. S > M	Not Supported
			DS > DM, $UM > US^{*}$	**.0404**	H16c. DM >> DS	**Opposite Direction Supported**
		appearing in One, Two, or Three Groups	D > U	**.0076**	**H16a. $D > U^{**}$**	**Supported**
				.8253	H16b. S > M	Not Supported
			DS > DM, $UM > US^{*}$	**.0456**	H16c. DM >> DS	**Opposite Direction Supported**
Quality of Ideas						
Importance of Ideas		Importance of Ideas (All Judges)		.7940	H14a. D > U	Not Supported
				.9366	H14b. M > S	Not Supported
				.4305	H14c. DM >> DS	Not Supported
		Importance of Ideas (Faculty Judges)		.7347	H14a. D > U	Not Supported
				.9453	H14b.M > S	Not Supported
				.1959	H14c. DM >> DS	Not Supported
Creativity of Ideas		Creativity of Ideas (All Judges)		.5380	H17a. D > U	Not Supported
				.5537	H17b. M > S	Not Supported
				.1018	H17c. DM >> DS	Not Supported
		Creativity of Ideas (Faculty Judges)		.6386	H17a. D > U	Not Supported
				.4259	H17b. M > S	Not Supported
				.6993	H17c. DM >> DS	Not Supported

Table 7.1 Summary of ANOVA Results (Continued)

Measure		Direction (Means)	P value	Hypothesis	Conclusion
Quality of Report					
Quality of Report	Content		.9018		
			.2753		
			.7367		
	Presentation		.3170		
			.3785		
			.6475		
	Overall		.8588	H18a. D > U	Not Supported
			.2916	H18b. M > S	Not Supported
			.7437	H18c. DM >> DS	Not Supported
Satisfaction					
Process Satisfaction			.3934	H19a. D > U	Not Supported
			.5491	H19b. DM >> DS	Not Supported
Cohesiveness			.6126	H21a. U > D	Not Supported
			.1853	H21b. DM >> DS	Not Supported
Supplementary Analysis: Production Efficiency					
Unique Ideas			.2142		
			.1505		
			.5086		
Rare Ideas	appearing in One Group		.9874		
			.2498		
		DS > DM, UM > US	**.0377***		
	appearing in One or Two Groups		.9632		
			.6796		
		DS > DM, UM > US	.0593		
	appearing in One, Two, or Three Groups		.7674		
			.5549		
		DS > DM, UM > US	.0614		

The findings of this study provide several insights into the communication process of asynchronous groups. First, the results suggest that asynchronous groups with facilitation supports by the Delphi structure are more productive in producing more total and per person ideas. In general, this result is consistent with the findings of Van de Ven and Delbeq (1971, 1974) and the previous EBS studies, which showed the superiority of a structured approach in idea generation tasks, but could have different interpretations.

Since the same amount of discussion time and the same communication medium (asynchronous CMC) were given to both the Delphi and the unstructured groups in this study, it is inferred that the significant difference in the number of ideas have only come from the difference in the communication structuring approaches.

Second, in asynchronous meeting environments, the medium-sized groups produce significantly more total ideas than the small-sized groups. This is consistent with the findings of the previous EBS experiments conducted in synchronous decision room settings. A distinctive finding of this study is that in asynchronous meeting environments, the small-sized groups produce significantly more per person ideas in discussion than the medium-sized groups and this significance was not found in the synchronous meeting environments. There are two possible interpretations of this discrepancy in the result of per person ideas between asynchronous and synchronous environments; this discrepancy could be due to either the difference in the communication mediums or the difference in the tasks used, or the combination of these two factors may have played a role. In synchronous GSS environments wherein members share the time of contributions, only a limited time is given to each member for his/her contributions. Furthermore, the tasks used in the prior synchronous GSS experiments have relatively a limited number of possible ideas compared to the Special Technology Inc. task used in this study. Thus, in the prior synchronous GSS experiments, the number of ideas produced by each member could have reached its maximum (due to the synchronicity of the communication medium and the nature of the task) before any free-riding effect occurred, especially in the medium-sized groups.

What does this result of the superiority of the small-sized group on the number of per person idea imply? Considering the characteristic of the task used in this study and the characteristic of the asynchronous communication medium that has no time limit for contributions and that members do not compete for an opportunity to contribute, it can be assumed that a person could have produced a new idea whenever it had occurred. Since there was no ceiling effect in the number of ideas produced with this task and there was no production blocking effect in asynchronous communication environments, it is inferred that a person in the medium-sized group was not as motivated to produce new ideas as a person in the small-sized group. This led to the conclusion that the free-riding effects in the medium-sized group may cause the small-sized group to produce more per person ideas.

Third, the superiority of Delphi structure and the small-sized groups in producing more per person ideas seems to come from the advantage of this structure that makes members participate more equally. This explanation is reasonable since the members in the Delphi groups or the small-sized groups participated in discussion more equally than the members in the unstructured groups or the medium-sized groups and there were also positive correlations between the equality of participation and the number of ideas produced.

Fourth, from the finding of the negative correlation between the quantity of ideas and perceived process gains or process satisfaction, it is inferred that information overload seem to occur when there are too many ideas produced.

Fifth, there was no interaction effect found between the structure and the group size in this study. In synchronous meetings, the production blocking effect is the most dominant process loss and larger groups suffer more severely from production blocking.

The previous EBS studies show that larger groups benefited more from the use of GSS in reducing the production blocking than smaller groups. On the contrary, the most dominant process gain of the Delphi structure was the reduction in the inequality of participation. In reducing the inequality of participation Delphi structure seems to be equally effective for both the small-sized group and the medium-sized groups.

Six, the use of Delphi communication structure is effective in transferring the members' discussion to the group report in good quality, since the positive correlation between the amount of the discussion and the quality of the group report only occurred in the Delphi condition, but not in the unstructured condition. The group coordinator's active participation in discussion relate to the quantity of unique ideas (both in discussion and in report) in the Delphi condition. But in the unstructured condition the group coordinator's active participation only relates to the amount of discussion, but not to the number of unique ideas. This finding also implies the efficiency of the Delphi structure where the informal leader directs the group to produce more unique ideas from the group discussion.

Seventh, the group coordinator's active involvement in discussion greatly affected the quality of the report. One possible explanation relates to the nature of facilitation used in this study. The facilitation mode used in this study is highly restrictive in the sense that the facilitator greatly relied on predefined rules or scripts and prohibited the facilitator's flexible guidance based on the dynamic situation of the group meetings. On the contrary, collaborative group report writing processes need more flexible involvement of the facilitator or the group coordinator so that he/she could promptly coordinate members' efforts and consolidate different members' contributions to a final product. Also in this process, the members' active participation and prompt responses to the need for their groups are critical. Considering the fact that the facilitation supports used in this study is highly restrictive and structured in nature, this result suggests that in producing quality work, the group leader's informal and flexible support for facilitating active participation of the group members is more effective than the highly structured facilitation with formal structure.

Eighth, even though there was no difference on the creativity of ideas between conditions, the Delphi structure may be effective for the group to produce more rare or novel ideas. This result confirms the previous belief that the members of the Delphi structure tend to produce more novel ideas because the individual idea generation of this structure ensures each member could exercise his/her best without interference from other members' contributions. However, in the Delphi condition, the quantity of rare ideas negatively correlates to the members' process satisfaction. The "rarity" measured in this study does not always mean "good quality". Since the members in the Delphi groups generate their ideas alone without worrying about others' negative opinions, the groups might feel that they produced too many "rare" but "not good" or "not feasible" ideas.

As well as the main effect of the structure, there was a significant interaction effect on the number of per person rare ideas between the structure and the group size; in producing rare ideas, the Delphi structure was more effective for the small-sized groups, while the unstructured approach was more effective for the medium-sized groups. This interaction effect was also supported for the efficiency of rare idea production; in producing rare ideas, the Delphi small-sized groups were significantly more efficient than the Delphi medium-sized groups and the unstructured medium-sized groups were significantly more efficient than the unstructured small-sized groups.

The comments by the subjects in the task questionnaire also shed important lights on asynchronous meeting processes. The subjects suggest flexible time of contributions, the equal opportunity for participation and reductions of evaluation apprehension as the advantages of asynchronous meetings over face-to-face meetings.

> "...everyone can work and participate according to his own schedule."
>
> "...sex or ethnics wasn't involving in how we relate to one another. No-one could judge me by my sex or race, just by my comments..."
>
> "...if this were a face-to-face task, I doubt we could have gotten along this well and participated equally."
>
> "The good thing about the task is that you could easily state opinions, and get feed back from various types of people who were not afraid to speak their minds, unlike in a class room setting where many would be hesitant."
>
> "I'm not exactly a fan of Webboard, and do not like using it for asynchronous learning. However, I do like asynchronous communication in the generation of ideas."

Many subjects had positive perceptions on the use of pen-name:

> "...the anonymity made it easier to discuss the validity of certain ideas without the pressure of criticism."
>
> "We did not know the members so there were no apprehensions and prejudices."
>
> "Pen name removed bias."
>
> "People who are afraid to speak out in front of groups would make it easier for them. Because we didn't use our own names, there was no discrimination or grouping amongst friends."
>
> "...anonymity can be a benefit and remove inhibitions people may feel about contributing ideas, or criticisms."

Even though the subjects said it was an interesting experience to conduct a group meeting on the Web, they raised many problems in asynchronous meetings. Lack of interactivity among members, impersonal communication, a long time lag between a message and a response, lack of participation, information overload, coordination problems due to the asynchronocity of the medium, and lack of consistent conversation were the problems the subjects responded that they had experienced during the experiment:

> "It's fairly hard to get a hold of the person if the person doesn't sign on at all. The collaboration is a good idea but it is hard to get the groups together and the group suffers even if it is only just one person who is not willing to do the work."

> "A group discussion only through Webboard was difficult because of low level of interactions and low level of involvement."

> "I understand that group interaction has to do with the main premise of the experiment, but from our perspective, that of the subject, it was difficult to get a point across if no one responds to your comment."

> "I have to wait for people to get back to me. The communication medium is not as effective as it is for face to face communication medium."

> "Asynchronous communication is good for brainstorming ideas but not good for discussion."

> "Using Webboard it is very difficult to actually have a consistent conversation. Sometimes people did not reply enough for there to be a meaningful conversation."

> "...it is not always easy to convey our messages over the internet without meeting or knowing the person you want to convey the message to."

The majority of the subjects said the coordination in group report writing was the most challenging task in the experiment. Considering the fact that writing a group report collaboratively is the sub-task which requires the most coordination among members, this response was expected. Some subjects, especially group coordinators, said it was difficult to solicit inactive members to participate more and the use of pen names aggravated this problem. Many of the subjects said it would have been more effective if they had been allowed to communicate through other synchronous media, especially chatting. Especially the members of the Delphi groups suggest the lack of time given to the sub-task (especially discussion after the voting and the short time to organize the group report after the second voting), lack of interactions among members, and too many repetitive ideas among the group members were the most critical problems they encountered:

> "…the task is to make groups interact more with each other I don't think that happened here at all. I personal had no interaction with group. I think if you have a group where you have to actively interact that would have been more interesting."

> "The real working world is comprised of teams where everyone is dependent on everyone to perform their stated tasks. This exercise was not team driven until the end when we all had to produce the final report."

Since the members of Delphi groups spent more time in individual process, they seem to have more difficulty in developing group cohesiveness. Since the restriction in the formal structure directed the Delphi groups how and when to exercise the task, the members of the Delphi groups may have had less opportunity in adapting themselves to a newly developed pattern of group interactions. As a result, this restrictive structure may have hindered them from developing the morale of working as a group.

The members of the unstructured groups often mentioned that they were able to understand the task better or to get hints from what other members were doing. The members of the Delphi groups did not mention this effect. However, the members of the unstructured groups often mentioned that they were frustrated when other members already posted the same idea ahead of them and they could not think of any other idea.

> "It is kind of hard to think up ideas that don't cross over to another person's idea."

> "I didn't like when people posted messages like "you are taking my idea"… I thought the task said to come up with new ideas or to elaborate on other's ideas."

On the contrary, the members of Delphi groups mentioned comments that they felt information overload from duplicated or similar ideas and they needed some mechanism for filtering or combining similar ideas. This was expected because in this experiment the facilitator removed only the exact duplications from the list of ideas the Delphi groups produced and the groups had no opportunity to reorganize their list by themselves.

Many of the members in the unstructured groups suggest that the group coordinator played a critical role in improving the performance of their groups, while the members in the Delphi groups never suggest the importance of the group coordinator in the group process:

> "(a group coordinator) I did not know where I should start acting as a group coordinator. Because pretty much most of the time, we were following the facilitator's instructions."

> "The group coordinator posted different instructions for the group report than the facilitator did."

These comments imply that the role of the group coordinator in the Delphi groups was contradicted with the role of the facilitator or was minimized because of the formal structure given to the groups. Even though this effect was not statistically tested in this study, these subjects' comments confirmed the findings of the previous studies (Hiltz et al., 1991; Ho and Raman, 1991) showing the canceling effect of two different facilitation sources.

In conclusion, this study shows that highly restrictive facilitation with the use of Delphi structure is effective for asynchronous groups to produce more unique and rare ideas. On the contrary, the group coordinator's informal supports to facilitate the group members' active participation are more important for producing better quality report. In asynchronous meetings, the medium sized groups generated more raw ideas than small-sized groups. On the contrary, in terms of per person ideas, the small-sized groups generate more ideas than the medium-sized groups. Different from the findings of the previous studies in synchronous meetings, in asynchronous meetings there was no interaction effect between the group size and the structure. However, the quantity of ideas does not relate to the members' satisfaction on the process, especially the Delphi groups are not happy when they are overloaded with too many rare ideas. The findings on the process gains / losses of this study suggest that contrary to synchronous meetings in which the production blocking plays a critical role, the equality of participation is more important factor to determine the productivity of asynchronous meetings. Even though the subjects found asynchronous meetings as an interesting new approach, they thought the meeting could have been more effective if the members had been coordinated each other through other synchronous type communication process such as chatting. It was inferred from the subjects' comments that the group coordinators played more critical role in the unstructured groups than in the Delphi groups. The role of the group coordinator was limited in Delphi groups because of the canceling effect between two different sources of facilitation—formal structure and leadership. The members of the unstructured groups felt more frustration when their idea generation was prohibited from the prior postings by other members, while the members of the Delphi group felt more frustration from overload of duplicated or similar ideas.

7.2 Contributions and Limitations

This study has the following contributions in the computer-mediated communications research area: (1) This study showed the effectiveness of the facilitated structure support (the Delphi structure) in asynchronous virtual teams. (2) This study is the first empirical study investigating the effect of group size in asynchronous group communication environments and identified important process gains / losses to determine the success of asynchronous meetings. (3) This study shows the importance of the use of pen-names in the computer-mediated communication environments and why pen-names contributed to the process. For example, the use of pen-names allows group members to observe the equality of participation and sources of ideas which are factors influencing various satisfaction measures.

This study also provided important insights to researchers and practitioners of Delphi. (1) From the previous literatures, this study identified the critical factors in implementing Delphi structure to facilitate asynchronous meetings and provided a new approach in implementing this structure through the Web-based asynchronous communication system. (2) This study is the first controlled experiment using the computer-based Delphi structure and it helps us to understand why and how this structure with computer support works for decision-making asynchronous groups. The use of computer-based implementation of Delphi structure in this study allows showing the effectiveness of the Delphi structure in decision-making asynchronous groups without confounding effects of the communication medium. (3) This study demonstrated the use of the morphological analysis approach (Zwicky, 1968) in identifying unique ideas. In the morphological analysis approach, the fundamental dimensions (three dimensions are used in this study; the subject being tracked, the information being gathered, and the implementation of the technology) within which any single item can be classified. Then any particular item in the content of the contributions can be coded in each dimension.

Despite of the above contributions, this study has the following limitations. First, as with all controlled experiments using students, the generalizability of results to "real" groups doing "real" tasks is somewhat in question. However, the policy analysis task for the groups in the study was "real" in the sense that it closely related to the course topics they were studying. The student subjects received a substantial part of their course grade, based on the quality and regularity of their participation. Thus, they were motivated to put their best efforts, even though it was a laboratory task. Moreover, analysis of the background questionnaires showed that 73% of the student subjects have been employed full-time in industry and 79% of the subjects thought they had the background to carry out the task. From these facts, it can be inferred the subjects do have some "real world" experience and background to complete this task.

The second limitation is the validity and the reliability of the current measurement method for the number of unique ideas and the task used in this study. A specific categorization method (categorization throughout the whole groups in terms of functions of tracking devices and subjects to be tracked) was used for the identification of unique ideas. The unique number of ideas could be different if other methods were used. However, the current method was based on a very conservative rule for testing the hypotheses; only the most specific concept counted as a unique idea in case the general and the specific concepts appeared in one group, which is more likely to occur in the Delphi condition wherein members do not have an opportunity to adjust the levels of granularity with one another. In this way the number of unique ideas appearing in the Delphi conditions would not be overestimated. However, alternative methods of identification should be developed and compared with the result of the current method to test the validity of the current method in future research.

This study also has some limitations in its reliability. Since the experimenter herself identified the raw ideas from the Webboard discussion and counted the number of ideas based on the categorization method and the general / specific rule, the measurement of the number of ideas was not done with absolute blindness to condition. However the experimenter exerted her best efforts to reduce the experimenter bias by applying consistent rules to all groups. Since the task used in this study (the Special Technology Inc. case) asked for different aspects of the application (target to be tracked, implementation method, purpose of tracking, information to be tracked, etc), the pool of possible ideas is much more diverse than the tasks used in previous synchronous GSS studies which asked much more focused concepts such as possible solutions of scenarios. Therefore, there is a possibility that the results of this study could be limited only to this specific task. Therefore, the hypotheses should be tested using different tasks in the future.

Because there was a limited number of student subjects that could be recruited in each semester, the group size used in this study was limited to the maximum of 12, which is relatively small for the usual Delphi groups. However, 6 vs. 12 was the typical cut-off points of group size used in the previous EBS studies and this enhances the comparability of this study.

There is also a limitation in the reliability of the treatment for Delphi facilitation. Since the experimenter played a role as a facilitator in the Delphi condition, there is a possibility of introducing experimenter bias. However the facilitation support used in this study followed a predefined script and strict rules for facilitation in the sense that the facilitator posted prescribed instructions at a predefined time and made minimum interventions only in case it was necessary, and followed strict rules when removing duplications. This restrictive approach in facilitation would enhance the replicability of this experiment to a reasonable level.

The last limitation is the low inter-judge reliability in idea / report evaluations. Due to the low Pearson R's among judges who evaluated the ideas or the reports (0.03-0.37 for Importance of Ideas, 0.09-0.40 for Creativity of Ideas, 0.44-0.70 for Overall Group Report Quality), the replicability of this evaluation is limited. Lack of inter-judge reliability on creativity might be partially due to the fact that the object tracking technology given in the task was currently available in the market and the subjects / the judges had different knowledge about the current applications of the technology. For example, one judge knew that tracking devices were currently used to track the location of athletes in some marathon competitions and to him this application was no longer creative. However this same application was considered very creative to the rest of the judges who did not know this application was currently available and thus gave it a very high rating on creativity. This problem also occurred in the process of voting in the experiment and the members' evaluations on creativity of the application. The judges and the subjects also felt that the evaluation criteria for the importance of the application were also not very clear. Even though the task said the subjects were supposed to evaluate the importance based on the consequences of the application, many of the subjects used different criteria such as marketability or feasibility of the application. Furthermore, the positive and negative consequences the subjects came up with for each application were mostly limited to convenience (positive consequence) and invasion of privacy (negative consequence). Some subjects also mentioned in the task questionnaire that the task failed to provide a variety of possible consequences due to the fact that the main functionality and purpose of the device are very specific (tracking the location and time of the object / people). The task should be changed in the future so that it will provide more diverse consequences of the device and clearer criteria for the voting so that the effect of the formal voting of the Delphi structure could be tested as well as the effect of individual idea generation.

7.3 Future Research

The most critical limitation of this study is the untested validity of the measurement method for identifying unique ideas and the task. Therefore, alternative methods or tasks should be developed and the same hypotheses be tested with these alternatives. As one alternative method, the morphological analysis approach used for identifying the unique ideas in this study should be extended in the way used in field Delphi studies; After a single item is classified and coded in each of the three dimensions, all possible combinations of these dimensions would be examined to see if the original contributor of this idea left out any significant new ideas hidden in the combinations of the entries in each dimension. By doing so, it would be possible to do a further evaluation of the results to see to what degree there were hidden ideas that could have been introduced in this manner and thereby to get a relative measure of the degree of novelty that actually occurred. Also the hypotheses should be tested using different tasks.

The analysis of the comments by the subjects led to unexpected findings—the potential canceling effect between facilitation and leadership. This effect should be investigated by the content analysis of the Webboard logs. Recent studies (on asynchronous group communications showed that the content analysis could provide useful insights to understand the dynamics of the group communication on the Web and these deep insights could not have been provided by quantitative measures only (Benbunan-Fich et al., 2002). Several coding schemes were developed for analyzing the content of synchronous meetings (DeSanctis and Poole, 1991; Sambamurthy and Poole, 1992; Zigurs et al., 1998) and each coding scheme was tailored to the purpose of the specific research question. Since the asynchronous group communications are very different from their synchronous counterparts, a new coding scheme for analyzing the contents of asynchronous meetings should be developed. Furthermore, this coding scheme should also be tailored to the analysis of the contents of facilitation and leadership.

The current analysis of the experiment is focused on the variables measured at a given time. In the future analysis, the interaction between the group development and the participation would be analyzed over time to see different levels of participation in time have different impacts on the group development. For the unstructured groups, the interaction between the timing of planning the group report and the quality of the report is worth of investigating.

This study showed the effectiveness of the specific structure of the Delphi which imposes individual idea generation in improving the productivity of idea generation. However, due to the shortcomings of the task discussed in Section 7.2, the effects of different aspects of the Delphi structures such as the formal voting could not be tested. Furthermore, this study has significant results only on the quantity of the ideas produced and the judge evaluations of the quality or the creativity measures do not provide useful results because of the lack of reliability. Therefore, the task should be improved in the future to incorporate better definition of technology, more focused definition of quality or creativity, and clearer criteria for voting. Especially considering the difficulty in consensus formation in asynchronous meetings, more studies should be done to investigate this issue.

To extend the generalizability of this study, the usefulness of the computer-based Delphi structure developed in this study should be also tested in real applications by the use of real experts. The current Delphi implementation heavily relies on the human facilitator who removes duplicated items and manually generates the voting questionnaire and report. The findings of this study suggest that members in Delphi groups were not satisfied when they were overloaded duplicated or similar ideas or rare but not very feasible ideas. These findings provide important implications on the effective design of the structured communication of asynchronous virtual teams; the system should provide meaningful unit of entries for contribution items (instead of entries for comments) and the teams should be able to reorganize these items in a collective manner. For this purpose, voting features which relate to the list of items should be incorporated so that the group members collaboratively can remove duplicated or unfeasible items from the further discussions, elaborate or reorganize the items by combining similar items. Also features of group report generation should be implemented to enhance the current voting process. The development and the empirical test of software features necessary to implementation of automated Delphi processes could answer the question of "Is automated facilitation by computer as effective as human facilitation?" or "If computer can be an effective source of facilitation in asynchronous, how much should the group depend upon it for guidance and restrictiveness?"

APPENDIX A

EXPERIMENT OVERVIEW

The following document was a Website that was used for providing potential subjects an overview of the experiment. The URL of this Website was given to the students in the recruiting process.

My name is Hee-Kyung Cho, a Ph.D. candidate in Information Systems. I am the experimenter who is coordinating this experiment and those of you, who chose to participate in an experiment for the assignment will follow my direction for the next few weeks.

Everything is sequential and you cannot skip one step before going to the next. PLEASE READ CAREFULLY and send me an email if you don't understand any part of it. I will try to answer within 24 hours.

This is an overview of the experiment.

I. Joining the Experiment (Please Do It Today!)

1. You HAVE TO send me an email to (heekyungexp@hotmail.com) so that I can include you for the experiment. Please be sure to use your official name, which shows on your school papers, and also try to use the email address you use most often. When I receive your email, I will assume you want to use that email address during the experiment. The message should include only your full name.

Please include the following in your message: Your name and the course / section OR your instructor's name which you want to receive the credits with this experiment. Anyone of you who already has participated in my experiment last semester CANNOT choose this assignment option and you should consult with your instructor for alternative assignment options.

Anyone of you who cannot log into webboard more than two days in a row during this experiment period (Nov 4 - Nov 22) CANNOT participate in the experiment.

II. Consent Form / Background Questionnaire / Experiment Participation Agreement (Due: Oct 21 Monday post marks)

2.You have to download (1) a Consent Form, (2) a Background Questionnaire and (3) a Experiment Participation Agreement, fill out those forms.

Consent Form
Background Questionnaire
Experiment Participation Agreement

3. You have to either mail or drop off the above forms to Experimenter.
You may drop off the forms in a box on which my name is printed in Co-lab (GITC4323). If you mail the forms, the address is 48 Fairway Terrace, Norwood NJ 07648.

I do NOT accept electronic submissions of a consent form and a background questionnaire.

IV. Webboard Training (Oct 21 Monday - Oct 31 Thursday)

4.Find the Webboard Training Tutorial at:
http://www-ec.njit.edu/~hkc7959/Experiment/lesson1.htm

If you are already familiar with the Webboard, you may skip the tutorial and find the FOUR Webboard training exercises at:
http://www-ec.njit.edu/~hkc7959/Experiment/exercise1.htm

5. As soon as you finish the Webboard Training Exercises APPROPRIATELY, Experimenter will assign you in an experiment group and email you a Training Completion Notification.

If you do not receive the above notification within 24 hours after you finish all the four Webboard training exercises, that means either you have missed any of these four exercises or you have done any of the exercises INCORRECTLY. You will be assigned in an experiment group ONLY if you finish ALL the four exercises correctly. If don't hear from me within 24 hours after you finish all the four exercises, you have to check the exercises and try again.

On Nov 3 Sunday, I will email you (1) the URL of your experiment webboard, (2) your pen-name (a new login ID which you will use to access your experiment webboard) and (3) a password to access the experiment webboard. As soon as you receive this information, you should log into the experiment webboard immediately and read all the instructions and information posted by Experimenter. If you don't receive the above information by Nov 3 Midnight, you should contact me immediately.

IV. Experiment (Nov 4 Monday - Nov 22 Friday)

6. During the three week's of the experiment, you should (2) log into your experiment webboard at least once a day, (2) follow all the instructions posted by Experimenter and (3) perform the task which will be posted in your experiment webboard cooperating with your group members. The task consists of several sub-tasks and it is extremely important for you to conform the due date of each sub-task.

V. Post-Experiment and Task Questionnaires (Due: Nov 26 Tuesday Midnight)

7. At the end of your three-week task period, you will see an attachment of a post-experiment questionnaire and a task questionnaire in your experiment Webboard. You have to fill in a post-questionnaire and send it to me via email, heekyungexp@hotmail.com

VI. Debriefing

8. In order to learn about this experiment, you should read a debriefing material after you submit the post-experiment and task questionnaires. I will send the URL of debriefing material after I receive your post-experiment and task questionnaires.

Email: heekyungexp@hotmail.com
Home Phone: 201-768-1220
Mobil Phone: 201-286-4347
Office Phone: 973-596-5422
Office: RM 4323, GITC

APPENDIX B

BACKGROUND QUESTIONNAIRE

The following is the background questionnaire used in the experiment. This questionnaire was distributed to the subjects before the experiment began.

BACKGROUND QUESTIONNAIRE

(cover sheet)**

Name: ______________________	Semester: ________________
Email: ______________________	Professor: ________________
Date: ______________________	Course #: ________________
	Section #: ________________

*** Please either drop off or mail this questionnaire to**

Hee-Kyung Cho
Collaborative Hypermedia Laboratory
Computer & Information Science
RM 4323 GITC
New Jersey Institute of Technology
University Height
Newark, NJ 07102

Email: heekyungexp@hotmail.com

** This page will be removed from your questionnaire and destroyed as soon as we put an identifying code on the other pages, in order to protect the confidentiality of your response.

The purpose of this questionnaire is to gather some background information. All information is confidential. (You are of course free to decide to answer any specific question)

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

1. My degree program (circle one): Bachelor's / Master's / Ph.D.

2. If Bachelor's, my year in school (circle one): Freshman/Sophomore/Junior/Senior/ 5th Year

3. My major: ______________________

4. English is my native or first language. (circle one): Yes / No;
   If you were **not born in the US**, the number of years you have lived in the US: __

5. My nationality is: ________________

6. My ethnic background is:
_____ Black / Afro American _______ Hispanic (Mexican, Puerto-Rican, etc.)

_____ White _______ Asian or Asian American
_____ Other, please specify__________________________

7. I am a: _____ female _____ male

8. My age at last birthday is: _____

9. I have used Webboard:
_____ Never ___ Once or twice _ Three to ten times _______ Frequently

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

11. I have been employed full-time in computer / information / telecommunication related company. (circle one): Yes / No

    If Yes, please specify the job title(s) and number of months you were employed in the corresponding job title(s). (e.g. 3 months in a system engineer)
    (Please list all if you were employed as more than two job titles.)
    ___ Months in a ______________________________________
    ___ Months in a ______________________________________
    ___ Months in a ______________________________________
    ___ Months in a ______________________________________
    ___ Months in a ______________________________________

Directions: Please respond to the following statements, by circling the answer that applies to you. There are no right or wrong answers. Work quickly and just record your first impression.

1. My level of expertise in identifying applications of pervasive computing technology is:
   Very high high medium low very low
   1---------------------2------------------3---------------------4-------------------5

2. My level of expertise in identifying social / privacy issues of new computer technology is;
   Very high high medium low very low
   1---------------------2------------------3---------------------4-------------------5

3. My confidence in identifying the consequences of computer technology in U.S. society would be:
   Very high high medium low very low
   1---------------------2------------------3---------------------4-------------------5

4. 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

5. My level of interests in pervasive computing technology is;
   Very high high medium low very low
   1---------------------2------------------3---------------------4-------------------5

6. My level of interests in social / privacy issues of computer technology is;
   Very high high medium low very low
   1---------------------2------------------3---------------------4-------------------5

7. My level of experience in working in groups in general is:
   Very high high medium low very low
   1---------------------2------------------3---------------------4-------------------5

8. I dislike participating in group discussions.
   Strongly agree Agree Undecided Disagree Strongly disagree
   1---------------------2------------------3---------------------4-------------------5

9. Generally, I am comfortable with participating in group discussions.
   Strongly agree Agree Undecided Disagree Strongly disagree
   1---------------------2------------------3---------------------4-------------------5

10. Engaging in group discussions with new people makes me tense and nervous.
Strongly agree Agree Undecided Disagree Strongly disagree
1----------------------2-------------------3-----------------------4---------------------5

11. Generally, I am comfortable with contributing my opinion / knowledge in my expertise areas.
Strongly agree Agree Undecided Disagree Strongly disagree
1----------------------2-------------------3-----------------------4---------------------5

12. I have easy access to Webboard from home or work.
Strongly agree Agree Undecided Disagree Strongly disagree
1----------------------2-------------------3-----------------------4---------------------5

APPENDIX C

FREQUENCY TABLES FOR BACKGROUND QUESTIONNAIRE ITEMS

The followings are the frequency tables for background questionnaire items. The frequency data was also given by the experiment condition (structure and group size).

Frequency of Sex by Structure

	Female		Male	
	N	%	N	%
Delphi	65	32.83	133	65.17
Unstructured	60	30.30	138	69.70
All	125	31.57	271	68.43

Frequency of Sex by Group Size

	Female		Male	
	N	%	N	%
Small-sized	50	37. 88	82	62.12
Medium-sized	75	28.41	189	71.59
All	125	31.57	271	68.43

Frequency of Age by Structure

	18-19		21-22		23-25		26-51	
	N	%	N	%	N	%	N	%
Delphi	40	20.30	66	33.50	50	25.38	41	20.81
Unstructured	33	17.01	58	29.90	59	30.41	44	22.68
All	73	18.67	124	31.71	109	27.88	85	21.74

Frequency of Age by Group Size

	18-19		21-22		23-25		26-51	
	N	%	N	%	N	%	N	%
Small-sized	28	21.37	39	29.77	38	29.01	26	19.85
Medium-sized	45	17.31	85	32.69	71	27.31	59	22.69
All	73	18.67	124	31.71	109	27.88	85	21.74

Frequency of Years in US by Structure

	0-4		5-10		11-17		18-28	
	N	%	N	%	N	%	N	%
Delphi	39	32.23	40	33.06	32	26.45	10	8.26
Unstructured	27	24.32	37	33.33	31	27.93	16	14.41
All	66	28.45	77	33.19	63	27.16	26	11.21

Frequency of Years in US by Group Size

	0-4		5-10		11-17		18-28	
	N	%	N	%	N	%	N	%
Small-sized	22	28.95	24	31.58	21	27.63	9	11.84
Medium-sized	44	28.21	53	33.97	42	26.92	17	10.90
All	66	28.45	77	33.19	63	27.16	26	11.21

Frequency of Degree Program by Structure

	Bachelor's		Master's	
	N	%	N	%
Delphi	117	90.77	18	9.23
Unstructured	176	89.34	21	10.66
All	353	90.05	39	9.95

Frequency of Degree Program by Group Size

	Bachelor's		Master's	
	N	%	N	%
Small-sized	116	87.88	16	12.12
Medium-sized	237	91.15	23	8.85
All	353	90.05	39	9.95

Frequency of Months of Full-time Employed by Structure

	0		1-12		13-24		25-60		Over 60	
	N	%	N	%	N	%	N	%	N	%
Delphi	57	29.08	60	30.61	23	11.73	36	18.37	20	10.20
Unstr.	50	25.77	61	31.44	27	13.92	40	20.62	16	8.25
All	107	27.44	121	31.03	50	12.82	76	19.49	36	9.23

Frequency of Months of Full-time Employed by Group Size

	0		1-12		13-24		25-60		Over 60	
	N	%	N	%	N	%	N	%	N	%
Small	36	27.69	45	34.62	19	14.62	22	16.92	8	6.15
Medium	71	27.31	76	29.23	31	1921.	54	20.77	28	10.77
All	107	27.44	121	31.03	50	12.82	76	19.49	36	9.23

Frequency of Computer-related Work Experiences by Structure

	Yes		No	
	N	%	N	%
Delphi	78	39.80	118	60.20
Unstructured	72	36.55	125	63.45
All	150	38.17	243	61.83

Frequency of Computer-related Work Experiences by Structure

	Yes		No	
	N	%	N	%
Small-sized	46	35.11	85	64.89
Medium-sized	104	39.69	158	60.31
All	150	38.17	243	61.83

Frequency of English as 1st language by Structure

	Yes		No	
	N	%	N	%
Delphi	84	43.75	108	56.25
Unstructured	92	49.20	95	50.80
All	176	46.44	203	53.56

Frequency of English as 1st language by Group Size

	Yes		No	
	N	%	N	%
Small-sized	58	46.03	68	53.97
Medium-sized	118	46.64	135	53.36
All	176	46.44	203	53.56

Frequency of Webboard Usage by Structure

	Never		Once of Twice		3-10 times		Frequently	
	N	%	N	%	N	%	N	%
Delphi	39	21.31	32	17.49	25	13.66	87	47.54
Unstructured	40	22.47	35	19.66	24	13.48	79	4438
All	79	21.88	67	18.56	49	13.57	166	45.98

Frequency of Webboard Usage by Group Size

	Never		Once of Twice		3-10 times		Frequently	
	N	%	N	%	N	%	N	%
Small-sized	39	21.31	32	17.49	25	13.66	87	47.54
Medium-sized	40	22.47	35	19.66	24	13.48	79	4438
All	79	21.88	67	18.56	49	13.57	166	45.98

APPENDIX D

CONSENT FORM

The following is the consent form used in the experiment. The subjects were asked to sign on this form before the experiment began.

Name of Project Director or Principal Investigators: **Hee-Kyung Cho**

Title of Project: **Social Decision Support Systems**

I acknowledge that on ___________________, I was informed by **Hee-Kyung Cho** (Investigators) of NJIT (under the supervision of Dr. Murray Turoff) of a project concerning or having to do with the following:
The study of the effect of the Delphi structure on small and large group communications

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

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

2. The following possible risks are involved:
   None; Confidentiality of the data will be fully protected.

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

4. The following benefits are expected by my participation:
   - An opportunity to learn about decision support and pervasive computing,
   - An opportunity to learn group decision making processes,
   - An opportunity to participate in Delphi surveys

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: ______________________________

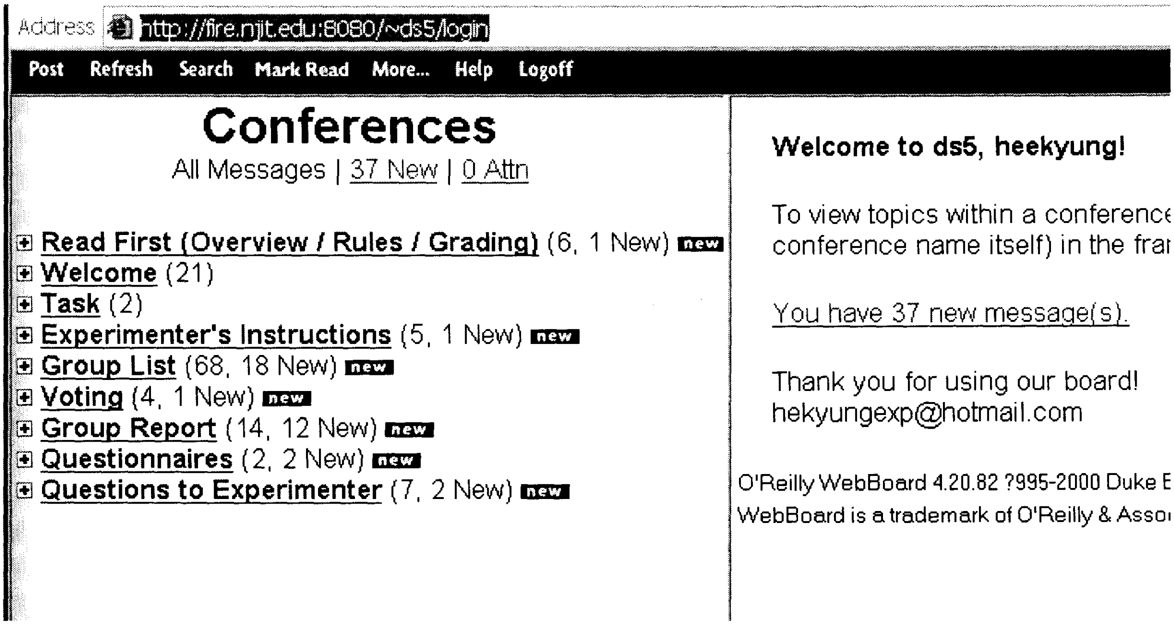
Date: ______________________________

Email address: ______________________________

APPENDIX E

EXPERIMENT WEBBOARD FOR DELPHI GROUPS

The following documents are the experiment instruments posted in the Webboard for the Delphi groups, which includes screen shots of the Webboard conferences and instructions of the experimenter.



Read First (Overview / Rules / Grading) conference:

i. Overview

Welcome aboard!!

Please read this schedule carefully and if you have any questions post them under the Questions to Experimenter conference.

Conference List:

- Read First: (Overview / Rules / Grading): **Read Only**
- Welcome
- Task: **Read Only**
- Experimenter's Instructions: **Read Only**
- Group List: **Moderated** (Feb 18 - Feb 24 only. Experimenter will change this conference to normal conference after that)
- Voting: **Read Only**
- Group Report:
- Questionnaires: **Read Only**
- Questions to Experimenter: (for any procedural or technical problem)

Read Only conference: You can only read but cannot post any messages in these conferences.

Moderated Conference: The message posted by you will not appear to other group members until the moderator (heekyung) of this conference reveals that message.

Experiment Schedule:

Date	What To Do	Conference	Allocated Points (Individual Performance)
Feb 18 (Mon) - Feb 19 (Tue)	1. Read Overview 2. Read Rules 3. Read Grading 3. Introduce yourself 4. Select a group coordinator	Read First Read First Read First Welcome Welcome	5 (No points for late postings
Feb 19 (Tue) Midnight	*1. Experimenter posts the task* *2. Experimenter posts the instruction for group report* *3. Experimenter posts the first instruction*	Task Group Report Experimenter's Instructions	
Feb 20 (Wed) -Feb 22 (Fri)	1. Generate the ideas of applications / uses	Group List	15
Feb 24 (Sun) Midnight	*1. Experimenter approves and reveals the initial list of applications / uses* *2. Experimenter makes Group List a normal conference* *3. Experimenter posts the second instruction*	Group List Group List Experimenter's Instructions	
Feb 25 (Mon) - Feb 27 (Wed)	1. Generate the consequences of each application / use 2. Generate any additional ideas of application / use	Group List Group List	15
Feb 27 (Wed) Midnight	*Experimenter posts the third instruction with the URL for the initial voting*	Voting	
Feb 28 (Thu) - Mar 1 (Fri)	Rate each application / use in terms five voting categories and provide the reasons (Due: Mar 1 Fri Midnight)	Voting	15 (No points for late postings)
Mar 2 (Sat) Midnight	*Experimenter posts the fourth instruction with the URL for report of the voting*	Voting	

	result of your group and the URL for the second voting		
Mar 4 (Mon) - Mar 5 (Tue)	1. Read the above report of the voting result 2. Discuss the voting result 3. Rate the applications / uses in terms of three categories and provide the reasons (Due: Mar 5 Tue Midnight)	Voting Group List Voting	15 (No points for late postings)
Mar 5 (Tue) Midnight	*Experimenter posts the fourth instruction with the URL for report of the result of the second voting*	Voting	
Mar 6 (Wed) - Mar 8 (Fri)	Work on the group report	---	
Due: Mar 8 (Fri) Midnight	Upload each part of the group report	Group Report	20 (-5 points for one day late)
Mar 9 (Sat) - Mar 12 (Tue)	1. Fill out the Post-Experiment questionnaire and Task questionnaire 2. Email the questionnaires (Due: Mar 12 Tue Midnight)	Questionnaires	15 (-5 points for one day late)
			Total: 100 points

Grading Policy:

Since you are already assigned in an experiment group, you will NOT able to be given an alternative assignment.

During the experiment, you will be asked to complete several sub-tasks. and points are allocated in those sub-tasks.

Different lateness policy will be applied to different sub-tasks.

Your contributions will be evaluated by Quantity, Quality and Regularity of your postings

ii. Rules:

Please read the following rules carefully. You HAVE TO follow those rules while you perform the experiment task.

- For the next two weeks, you are working with the other **Five** members of your group in this discussion board.
- The **OBJECTIVE** of your group is to generate a group report on the task that will be posted in Task conference.
- The entire discussion process consists of a series of **Individual** contributions and **Group** feedback.

  In **Experimenter's Instructions** conference, the experimenter will post step-by-step instructions of WHAT / WHERE / until WHEN you have to post . It is very important to follow those instructions. **You have to keep the due date for each step.**
- You MUST log in at least once every day.
- You are not permitted to discuss this task using other media such as telephone, emails, any kind of chatting form, face-to-face meetings; USE ONLY this Webboard system.
- You can login this system using the login ID (your pen-name) given by the experimenter ONLY. You are not permitted to log in using other login ID's. You are not permitted to use your real name in your postings.

IMPORTANT: Please keep your pen-name and the password (which was given by Experimenter) in a safe place since you will be asked these two information in later steps of the experiment.

Experimenter: Hee-Kyung Cho

home: (201)768-1220
cell: (201)286-4347
office: (973) 596-5422

iii. Grading:

Grading:

Since you are already assigned in an experiment group, you will NOT able to be given an alternative assignment.

Your grade will be based on *Individual Performance* (the performance of your own: **70%**) and *Group Performance* (the performance of your group as a whole: **30%**).

Individual Performance:

Individual Performance is based on the following grading scheme:

Sub-Task	Points	Late Penalty
Introduction / Selection of group coordinator	5	No points for late postings
Idea Generation	15	
Consequence Development	15	
Initial Voting	15	No points for late postings
2nd Voting	15	No points for late postings
Group Report	20	-5 points for one day late
Task and Post Experimental Questionnaires	15	-5 points for one day late
Total	100	

Your contributions will be evaluated by Quantity, Quality and Regularity of your postings.

Group Performance:

Group Performance is calculated by averaging the individual performance of your group members.

Welcome conference:

Welcome:

Welcome !!!

For the next two days (Feb 18 - Feb 19) in this conference:

- Each of you is asked to introduce yourself to the other members of your group. You can say about your professional background but you cannot mention your real name in your introduction.
- Your group is asked to select a **group coordinator.**

A group coordinator will have the following responsibility:

- To make sure your group finish all the sub-tasks on time

- To allocate the three sections of the group report to three teams of your group members and to make sure to distribute each member's workload equally

A group coordinator will have 10 extra points (out of 100) for his/her well-done job.

- Please read **Overview** / **Rules** / **Grading** in **Read First** conference carefully.

- On Feb 19 (Tue) midnight, Experimenter will post the task in **Task** conference and the first instruction in **Experimenter's Instructions** conference.

Experimenter's Instructions conference:

i. Instruction for Initial Idea Generation:

During the next three days;

(In **Group List** conference)

- You are asked to post a list of (as many as) applications or uses of the newly-developed object-tracking device you can possibly think of.

- In each application, you have to include **Title**, **Keywords** and **Description** of that application / use (See **Part 1** of **Task** in **Task** conference for detail).

- There is a root comment "**Application List**" posted by Experimenter in **Group List** conference. When you post a new application idea,

  - First, you have to REPLY (Not POST) to the comment "**Application List".**

  - When you reply, the original title of the message (**Application List**) will appear in the edit box of topic. You have to change the topic (title) of the message into the **Title** of the application (the one included in your message body).

  - Since **Group List** is a moderated conference, you will not able to see messages posted by others. But you will be able to see your OWN message if you post that message by replying to my comment "**Application List". Just click this message, then your message will appear in the right frame.**

- Since each of you post your ideas individually without seeing each other's contributions, there might be some duplications. Among the messages which express the exact duplicate ideas, only the first message will remain and Experimenter will delete the other messages from **Group List** conference. But Experimenter will keep and store a copy of all messages deleted from **Group List** conference.

ii. Instruction for Consequence Development:

- Experimenter approved and revealed all comments posted in **Group List** conference, eliminate duplications and change this conference into a normal conference. Therefore from now on, all the messages will appear to you right after it is posted.

- During the next three days, you are asked to do the followings:

  1. (In **Group List** conference): Read the initial list of applications / uses developed by your group.

  2. (In **Group List** conference): For each application / use, post any development or improvement in the current **Title** / **Keywords** / **Description** by REPLYing to the corresponding comment (**REPLY!**, not post).

     (See **Part 1** of **Task** in **Task** conference for details)

  3. (In **Group List** conference): For each application / use, post **Positive consequences** and/or **Negative consequences** for that application / use by REPLYing to the corresponding comment (**REPLY!**, not post).

IMPORTANT: DO NOT CHANGE THE TOPIC (title of the message) WHEN YOU REPLY. All the comments which are replied to an application should have the same topic (i.e. Title of the application).

(See **Part 2** of **Task** in **Task** conference for details)

  4. (In **Group List** conference): Add more applications / uses of the newly-developed object-tracking device, if you get inspiration from ideas of other group members.

iii. Instruction for Initial Voting

During the next TWO days, you are asked to do the following:

- (In **Group List** conference): Read the final list of applications / uses and the comments contributed by your group members.

- Initial Voting:

1. (In **Voting** conference): In the comment "**Initial Voting**", Experimenter posted the URL of the questionnaire in which you will rate each application / use in terms of its relative importance (five scales). You have to click that URL to initiate a form of the questionnaire.
2. At the first part of the questionnaire, you will be asked to provide your **pen-name** and **password** (which was given by Experimenter at the beginning of the

experiment). Any questionnaire entered with the wrong pen-name or password will NOT be used in the subsequent voting analysis. Therefore, be sure to provide the correct pen-name and password. If you don't remember your pen-name or password, ask Experimenter.
3. After you enter your pen-name and password, you will be asked to rate each application / use in terms of its relative **importance** and also be asked to provide the **comment** on that application. Please provide the reason of your judgment (rating) in the comment.
Warning: Do not use ENTER key when you type in the comment.
4. At the end of the questionnaire, you will be asked to provide general comment on the list of applications / uses overall.
5. After you fill out the questionnaire, you have to click "submit" button to submit the questionnaire.

- Experimenter will post the URL for the report of the voting result of your group by March 2 (Sat) midnight.

iv. Instruction for 2nd voting

During the next TWO days, you are asked to do the following:

- (In **Voting** conference): Read the report of voting result (the URL of this report is posted in **Initial Voting Result**.)

- (In **Group List** conference): Discuss the voting result (e.g., whether you agree or disagree with the result).

- 2nd Voting

  1. (In **Voting** conference): In **2nd Voting**, Experimenter posted the URL of the 2nd questionnaire in which you will rate each application / use in terms of its relative importance (three scales). You have to click that URL to initiate a form of the questionnaire.
  2. At the first part of the questionnaire, you will be asked to provide your **pen-name** and **password** (which was given by Experimenter at the beginning of the experiment). Any questionnaire entered with the wrong pen-name or password will NOT be used in the subsequent voting analysis. Therefore, be sure to provide the correct pen-name and password.
  3. After you enter your pen-name and password, you will be asked to rate each application / use in terms of its relative **importance**. Please provide any **comment** if you changed your initial judgment and/or you would like to influence on other members' judgments.

Please do not repeat your comments that you provided in the first voting. You do not need to comment on all the applications.

4. At the end of the questionnaire, you will be asked to provide general comment on the list of applications / uses overall.
5. After you fill out the questionnaire, you have to click "submit" button to submit the questionnaire.

Due: Mar 5 Tue Midnight

v. Group Report Writing

- (In **Voting** conference) Experimenter posted a comment **2nd Voting Result** with the URL for a report of the 2nd voting result of your group. Click that URL and read the report.

During the next THREE days:

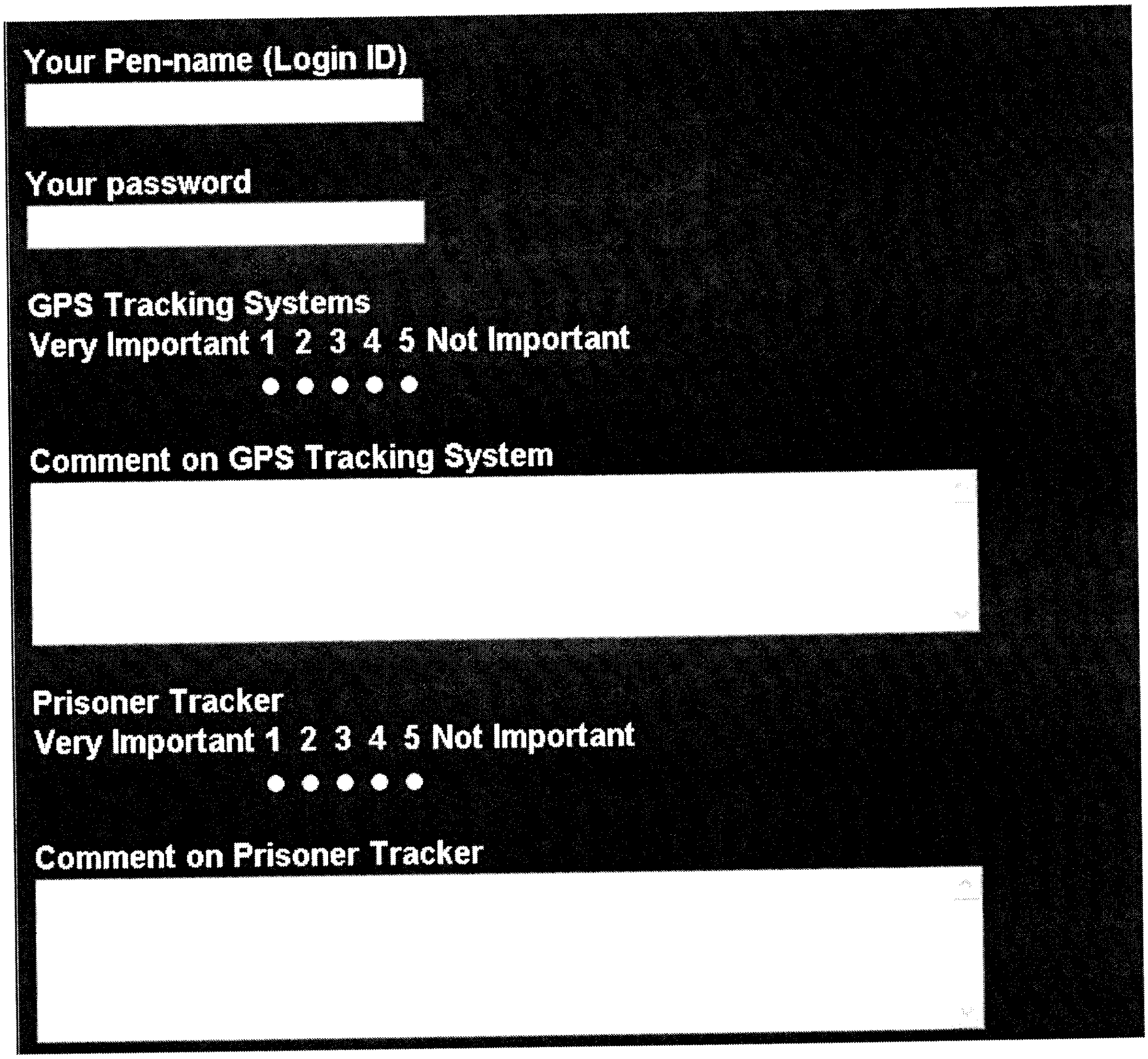
- (In **Group List** conference) Discuss the 2nd voting result and decide in which category of relative importance your group should put each application / use.

- (In **Group Report** conference) With the initiation of the group coordinator, divide the workload of the group report.

- Each part of the group report will have to be uploaded in **Group Report** conference with a Word Document (**.doc**) attachment (**Due: Mar 8 (Fri) Midnight**).

Voting conference:

Voting Questionnaire


Your Pen-name (Login ID)

Your password

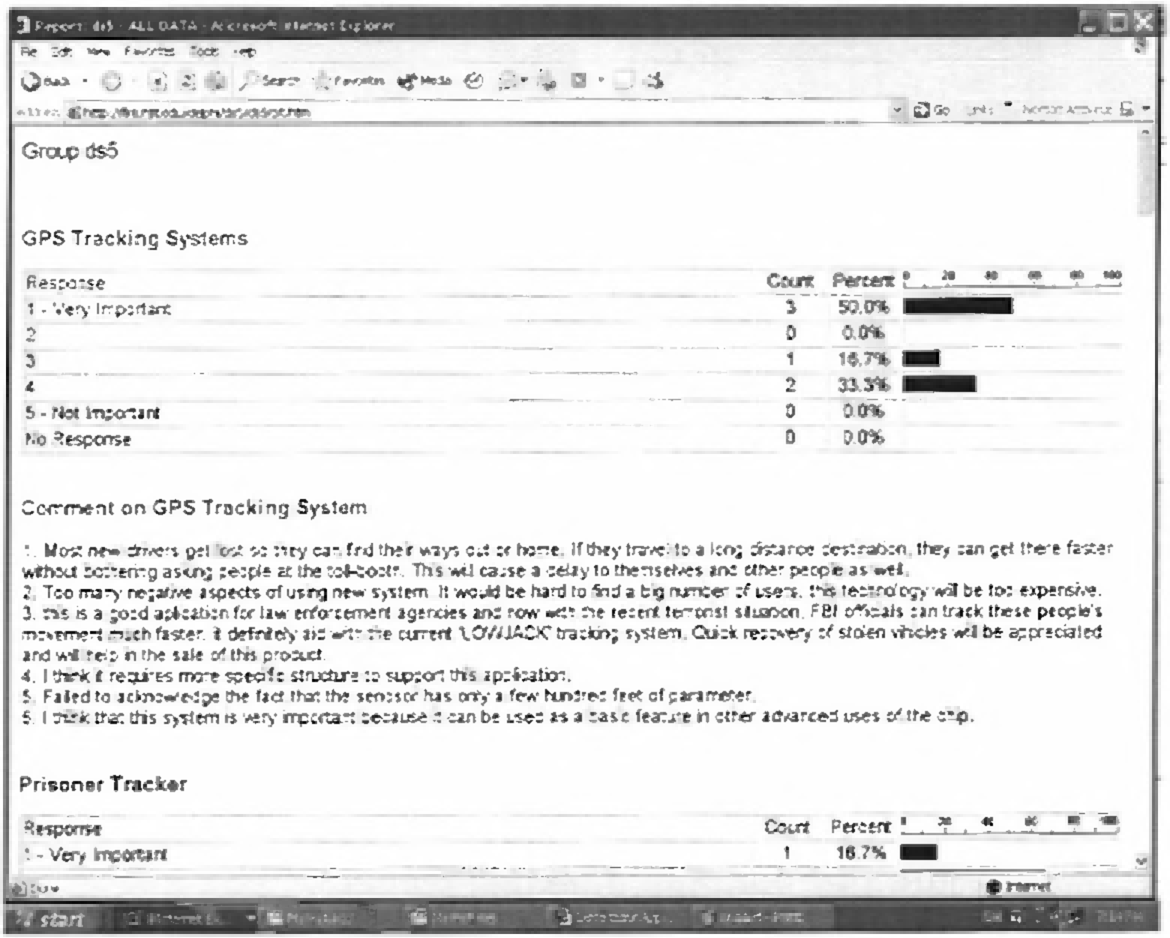
GPS Tracking Systems
Very Important 1 2 3 4 5 Not Important

Comment on GPS Tracking System

Prisoner Tracker
Very Important 1 2 3 4 5 Not Important

Comment on Prisoner Tracker

Voting Report



Group ds5

GPS Tracking Systems

Response	Count	Percent
1 - Very Important	3	50.0%
2	0	0.0%
3	1	16.7%
4	2	33.3%
5 - Not Important	0	0.0%
No Response	0	0.0%

Comment on GPS Tracking System

1. Most new drivers get lost so they can find their ways out or home. If they travel to a long distance destination, they can get there faster without bothering asking people at the toll-booth. This will cause a delay to themselves and other people as well.
2. Too many negative aspects of using new system. It would be hard to find a big number of users. this technology will be too expensive.
3. this is a good aplication for law enforcement agencies and now with the recent terrorist situation. FBI officials can track these people's movement much faster. it definitely aid with the current 'LOWJACK' tracking system. Quick recovery of stolen vhicles will be appreciated and will help in the sale of this product.
4. I think it requires more specific structure to support this application.
5. Failed to acknowedge the fact that the sensor has only a few hundred feet of parameter.
5. I think that this system is very important because it can be used as a basic feature in other advanced uses of the chip.

Prisoner Tracker

Response	Count	Percent
1 - Very Important	1	16.7%

Group Report conference:

Group Report Specification:

- Your group report should include THREE sections: **each section represents one category** among the three categories (**Very Important**, **Some Important**, **Not Important**) which were described in Task. Each section will include a short concise **introduction** of any general observations appropriate to the whole category (If there are specific consequences or considerations that cut across all the applications or uses in that section they should become part of the introduction to that category) followed by:

- Each **application** or use in that category followed by the (positive and negative) **consequences** developed for that item
- Any **other comments** relevant to the specific application and considered significant, such as the reason why your group put this application into the corresponding category

The contents of group report should be based on your group discussion, not based on your personal opinion.

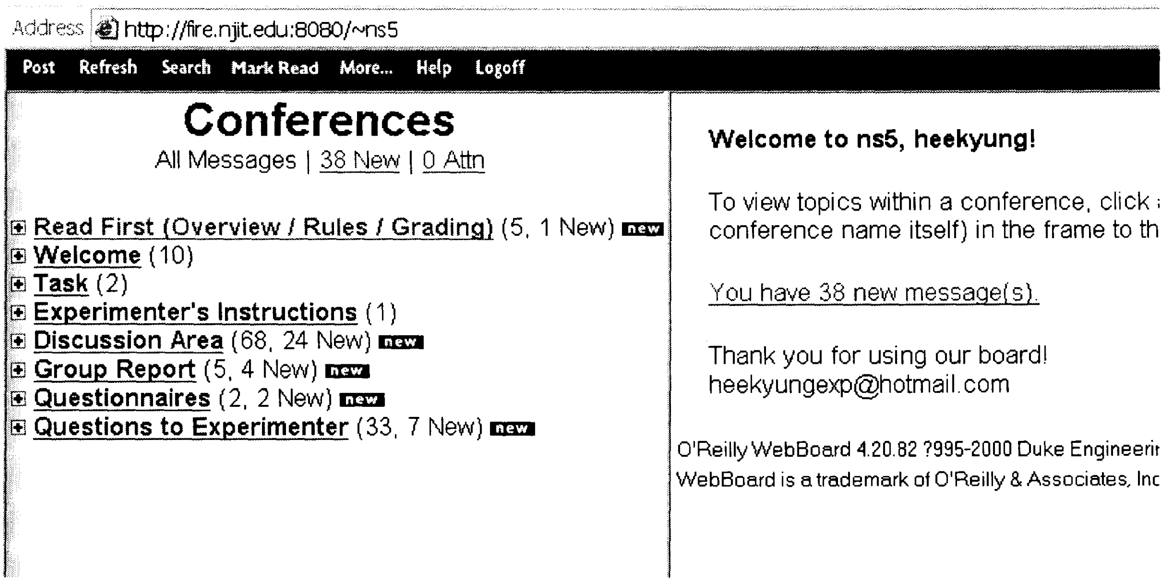
The group coordinator should make sure that the workload of writing a group report will be equally distributed to every group member.

- (In **Group Report** conference) Each section of group report has to be uploaded with a **.doc** (Word document) attachment by Mar 8 (Fri) midnight.

APPENDIX F

EXPERIMENT WEBBOARD FOR UNSTRUCTURED GROUPS

The following documents are the experiment instruments posted in the Webboard for the unstructured groups, which includes screen shots of the Webboard conferences and instructions of the experimenter.



Read First (Overview / Rules / Grading) conference:

i. Overview

Welcome aboard!!

Please read this schedule carefully and if you have any questions post them under the Questions to Experimenter conference.

Conference List:

- Read First : (Overview / Rules / Grading) **Read Only**
- Welcome:
- Task: **Read Only**
- Experimenter's Instructions: **Read Only**
- Discussion Area: (The conference you will be using for performing the task)
- Group Report:
- Questionnaires: **Read Only**
- Questions to Experimenter: (for any procedural or technical problem)

Read Only conference: You can only read but cannot post any messages in these conferences.

Experiment Schedule:

Date	What To Do	Conference	Allocated Points (Individual Performance)
Feb 18 (Mon) - Feb 19 (Tue)	1. Read Overview 2. Read Rules 3. Read Grading 3. Introduce yourself 4. Select a group coordinator	Read First Read First Read First Welcome Welcome	5 (No points for late postings)
Feb 19 (Tue) Midnight	*1. Experimenter posts the task*	Task	
	2. Experimenter posts the instruction for discussion	Experimenter's Instructions	
	3. Experimenter posts the specification of group report	Group Report	
Feb 20 (Wed) - Mar 8 (Fri)	1. Read the instruction posted by Experimenter	Experimenter's Instructions	20 points for Part 1 in Task 20 points for Part 2 in Task 20 points for Part 3 in task
	2. Read the group report specification posted by Experimenter	Group Report	
	3. Discuss and perform the task	Discussion Area	
	4. Work on your part of the group report	---	
Due: Mar 8 (Fri) Midnight	Upload each part of group report	Group Report	20 (-5 points for one day late)
Mar 9 (Sat) - Mar 12 (Tue)	1. Fill out the Post-Experiment questionnaire and Task questionnaire 2. Email the questionnaires (Due: Mar 12 Tue Midnight)	Questionnaires	15 (-5 points for one day late)
			Total: 100 points

Grading Policy:

Since you are already assigned in an experiment group, you will NOT able to be given an alternative assignment.

During the experiment, you will be asked to complete several sub-tasks. and points are allocated in those sub-tasks.

Different lateness policy will be applied to different sub-tasks.

Your contributions will be evaluated by Quantity, Quality and Regularity of your postings

ii. Rules

Please read the following rules carefully. You HAVE TO follow those rules while you perform the experiment task.

- For the next two weeks, you are working with the other **Five** members of your group in this discussion board.
- The **OBJECTIVE** of your group is to generate a group report on the task that will be posted in **Task** conference.
- In **Experimenter's Instructions** conference, the experimenter will post a comment **Instruction** with an instruction of HOW your group should perform the task. It is very important to follow that instruction.
- You MUST log in at least once every day.
- You are not permitted to discuss this task using other media such as telephone, emails, any kind of chatting form, face-to-face meetings; USE ONLY this Webboard system.
- You can log into this system using the login ID given by the experimenter ONLY. You are not permitted to log in using other login ID's. You are not permitted to use your real name in your postings.

Experimenter: Hee-Kyung Cho

home: (201)768-1220
cell: (201)286-4347
office: (973) 596-5422

iii. Grading

Grading:

Since you are already assigned in an experiment group, you will NOT able to be given an alternative assignment.

Your grade will be based on *Individual Performance* (the performance of your own: **70%**) and *Group Performance* (the performance of your group as a whole: **30%**).

Individual Performance:

Individual Performance is based on the following grading scheme:

Sub-Task	Points	Late Penalty
Introduction / Selection of group coordinator	5	No points for late postings
Idea Generation (Part 1 in Task)	20	
Consequence Development (Part 2 in Task)	20	
Voting (Part 3 in Task)	20	
Group Report	20	-5 points for one day late
Task and Post Experimental Questionnaires	15	-5 points for one day late
Total	100	

Your contributions will be evaluated by Quantity, Quality and Regularity of your postings.

Group Performance:
Group Performance is calculated by averaging the individual performance of your group members.

Welcome conference:

Welcome:

Welcome !!!

For the next two days (Feb 18 - Feb 19) in this conference:

- Each of you is asked to introduce yourself to the other members of your group. You can say about your professional background but you cannot mention your real name in your introduction.

- Your group is asked to select a **group coordinator**.

  A group coordinator will have the following responsibility:

  - To make sure your group finish all the sub-tasks on time

  - To allocate the three sections of the group report to three teams of your group members and to make sure to distribute each member's workload equally

A group coordinator will have 10 extra points (out of 100) for his/her well-done job.

- Please read **Overview / Rules / Grading** in **Read First** conference carefully.

- On Feb 19 (Tue) midnight, Experimenter will post the task in **Task** conference and the instruction in **Experimenter's Instructions** conference.

Experimenter's Instructions conference:

Instruction:

- During Feb 20 (Wed) - Mar 8 (Fri), your group is asked to carry out the **Task** (the Special Technologies Inc. Case) posted in **Task** conference. The objective of your group is to generate a group report.

- (In **Discussion Area**) Each of you can do the followings:

  - Contribute your own ideas of applications / uses, by POSTing a root comment representing each application / use (**POST**, not Reply). When you post your idea, you have to change the topic (the title of the message) to the Title of the application / use (the one included in your message body).

  (See **Part 1** of **Task** in **Task** conference for details)

  - Contribute your own ideas of positive and negative consequences of each application / use and/or other relevant comments, by REPLYing to the corresponding root comment representing each application / use (**REPLY**, not Post).

  (See **Part 2** of **Task** in **Task** conference for details)

  - Comment on each application / use which was already posted by himself/herself or other members with your judgment of whether you think this application / use belongs in a particular category of relative importance, by REPLYing to the corresponding root comment representing each application / use (**REPLY**, not Post).

  (See **Part 3** of **Task** in **Task** conference for details)

- (In **Discussion Area**) Your group may devise any method they want to determine if a given application / use belongs in a given category for the group report. (See **Part 3** of **Task** in **Task** conference for details)

In Group Report conference:

Group Report Specification: same as Delphi groups

APPENDIX G

TASK

The following is the task used in the experiment. This task was posted in the Task conference in the Webboard.

Special Technology Inc. Case

Special Technologies Inc. is a manufacturing company which has been developing computer chips for 30 years. This company has been a leader in the computer chip manufacturing industry by making significant R&D efforts in this field. The R&D department of Special Technologies Inc. has just developed a new object-tracking device that has a tiny computer chip inside.

The device has the following properties:

- It is about the size of pill and may be attached to any object or a person internally or externally.
- The device can be detected by a rather simple relatively inexpensive active sensor from a few hundred feet away and which can obtain the data stored in the device.
- The device can be integrated with other sensors which can input data to this small computer.
- The device could be integrated with objects like cell phones to send its own signal into a digital network.

For example, similar, but much more primitive, technology was already applied to EZPASS for toll payments. Recently, the use of EZPASS has been expanded for enforcement of speed limits, beyond its original intended purpose.

The R&D department has made efforts to determine possible applications or uses for this technology along with the possible implications of those applications; however the individuals in that operation do not feel confident about their current review of implications of the device. Most of their effort has been focused on the technology objectives:

(1) to minimize the size and weight of this device
(2) to maximize the possible use of this device by developing small integrated sensors (e.g. audio, video, temperature, location, etc.).
(3) to integrate technology to deliver the device (e.g. being able to travel through the small intestines as it sends photos of the internal walls).
(4) to improve the price-performance ratio.

The R&D Department has determined it has made sufficient progress that the company needs to determine the potential market including the possible applications and their consequences.

The head of the R&D department reported to John Smith, President of Special Technologies Inc. that this new device is ready to be marketed from a technical point of view. John Smith was thrilled to hear this report because it was his long-held belief that there would be enormous utility for this object-tracking technology and there would be ample benefits of using this device in many applications, which we could not have thought of before. On the other hand, he knew the possible dangers of marketing this device without understanding the full range of possible applications and what safeguards might be necessary to insure the device is not used in harmful ways. He strongly believes that it is crucial for his company's long-term success to respond to social needs in terms of social responsibility as an industry leader.

Therefore, John Smith decided to hire a team of consultants who would come up with different applications for this newly developed object-tracking device and assess the possible consequences of each application. After gathering possible scenarios of different applications and analyzing the positive and negative consequences of each application, John Smith will invest his company's marketing resources to the most appropriate application(s).

Your company is considered an elite group of creative professionals that is able to develop and assess the implications of new technology. Your group is the working team the company has put together to do the following study:

Part 1. List as many different applications or uses of the newly-developed object-tracking device your group can possibly think of. An application is any use to which someone, some country, some organization, some social group or professional group can put this technology. You are to determine applications and/or uses regardless of how positive or negative you might think a particular application to be.

In each application, you have to specify;

Title: A name for each tracking technology application

Keywords: A list of words that best specifically describe each application

Description: A brief description of what it is and what it might track. Which, as appropriate, could include:

- What is the purpose of using this device
- Who or what organization, group (etc.) would pay for using and/or developing this application?
- What are the objects or people who will interact with the device?
- What information or data is the device obtaining and where is the resulting data used and by whom?

Once someone has come up with the initial application or use, the development or improvement of the above points may well result from other members of the group contributing to the initial concepts.

Part 2. For each application or use the group develops, the group is also expected to come up with two or more significant Positive and/or Negative Consequences for that application or use.

- **Positive Consequences:** Possible positive impacts of each application to our society or the world, including specification of who or what will benefit by this application.
- **Negative Consequences:** Possible negative impacts of each application to our society or the world, including specification of who or what will be impacted

As a group, try to express two or more consequences for each of the applications or uses suggested. Since good or bad can be relative to the situation you may wish to comment on such things as what social or ethical view you are using.

Part 3. Finally, for the final report the group must determine which applications or uses fall in the following three categories

Very Important: The consequences of this application have the greatest possible potential for impact on our world whether that impact is negative or positive. There is some organization that will pay any amount they can raise to make this use of the technology. For negative consequences it is not yet clear how to protect against them.

Somewhat Important:

Not Important: This application is unlikely to be useful or wanted. Or this is a minor variation or duplication of another application.

Group Report: The group report will have a section for each of three categories with a short concise introduction of any general observations appropriate to the whole category followed by:

- Each application or use in that category followed by the consequences developed for that item.
- Any other comments relevant to the specific application and considered significant.

If there are consequences or considerations that cut across all the applications or uses in that section they should become part of the introduction to that category.

Minority Report: If any one does not agree with the final group view presented in the report they may file a minority report pointing out what they don't agree with and why.

APPENDIX H

TASK SURVEY

The following is the task survey used in the experiment. This survey was posted in the Webboard conference at the end of the experiment and the subjects were asked to fill out and submit by email.

Special Technology Inc. Case Task

(cover sheet*)

Name: ______________________________

Date: ______________________________

Pen-name (Login ID): ______________________________

Please send this questionnaire as an email attachment to heekyungexp@hotmail.com or mail back to

Hee-Kyung Cho
Collaborative Hypermedia Laboratory
Computer & Information Science
RM 4323 GITC
New Jersey Institute of Technology
University Height
Newark, NJ 07102

* This page will be removed and destroyed from your questionnaire as soon as we have put identifying code on the other pages, in order to protect the confidentiality of your responses.

Please complete this questionnaire AFTER you have completed work on the task.

Part I. Please rate the task on each of the following dimensions by writing down the number which most closely matches your opinion in the bracket [ ].

[ ] 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, instruction, procedure, vocabulary, etc). **PLEASE PRINT.**

2. What are good things and bad things about the task? **PLEASE PRINT.**

APPENDIX I

POST-EXPERIMENT QUESTIONNAIRE

The following is the post-experiment questionnaire used in the experiment. This survey was posted in the Webboard conference at the end of the experiment and the subjects were asked to fill out and submit by email.

Special Technology Inc. Case Task

(cover sheet**)

Name: ___________________________________

Date: ___________________________________

Pen-Name (Login ID): ________________________________

Please send this questionnaire as an email attachment to heekyungexp@hotmail.com

or mail back to

Hee-Kyung Cho
Collaborative Hypermedia Laboratory
Computer & Information Science
RM 4323 GITC
New Jersey Institute of Technology
University Height
Newark, NJ 07102

** This page will be removed from your questionnaire and destroyed as soon as we put an identifying code on the other pages, in order to protect the confidentiality of your response.

The questions that follow make it possible to describe objectively certain characteristics of groups. The items simply describe characteristics of groups; they do not judge whether the characteristic is desirable or undesirable. Therefore, in no way are the questions to be considered a "test" either of your group or of the person answering the questions. We simply want an objective description of what your group was like. Therefore, please choose one number based only on your experience with your group.

Please rate on each of the following dimensions by writing down the number which most closely matches your opinion in the bracket [ ] before each item.

[ ] 1. Did you feel any apprehension about generating your ideas?
A lot of apprehension 1----2----3----4----5 No apprehension

[ ] 2. This group process emphasized the value of questioning assumptions.
Not at all 1----2----3----4----5 Very much

[ ] 3. How much do you feel you participated in this task?
Not much 1----2----3----4----5 A lot

[ ] 4. How interesting was this group process?
Very uninteresting 1----2----3----4----5 Very interesting

[ ] 5. There was a high degree of participation on the part of members.
Strongly agree 1----2----3----4----5 Strongly disagree

[ ] 6. Only a few members dominated the group discussion.
Strongly agree 1----2----3----4----5 Strongly disagree

[ ] 7. How satisfied are you with the quality of the ideas your group proposed?
Very satisfied 1----2----3----4----5 Very unsatisfied

[ ] 8. How at ease were you during the idea generation process?
Definitely not at ease 1----2----3----4----5 Very at ease

[ ] 9. The work of the group was well divided among members.
Strongly agree 1----2----3----4----5 Strongly disagree

[ ] 10. How stimulating did you find this group process?
Not stimulating 1----2----3----4----5 Very stimulating

[ ] 11. This group process got me to look at problems from many different angles
Not at all 1----2----3----4----5 Very much

[ ] 12. One person influenced the group's work more than the rest of the group.
Strongly agree 1----2----3----4----5 Strongly disagree

[ ] 13. The group process uncovered valid alternatives that I had not considered.
Strongly agree 1-----2----3----4----5 Strongly disagree

[ ] 14. This group process made me re-examine critical assumptions to question whether they are appropriate.
Not at all 1----2----3----4----5 Very much

[ ] 15. How confident are you in your group's ideas and opinions?
Very confident 1-----2----3----4----5 Very unconfident

[ ] 16. Every member of the group did not have a job to do.
Strongly agree 1----2----3----4----5 Strongly disagree

[ ] 17. How satisfied with *your own performance* on this task?

Very unsatisfied 1-----2----3----4----5 Very satisfied

[ ] 18. After this group process, I developed the ability to communicate clearly about the topic.

Strongly agree 1----2----3----4----5 Strongly disagree

[ ] 19. 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

[ ] 20. This group process encouraged addressing problems by using reasoning and evidence, rather than unsupported opinion.

Not at all 1----2----3----4----5 Very much

[ ] 21. After this group process, I gained a good understanding of the subject area of object tracking technologies and their applications.

Strongly agree 1----2----3----4----5 Strongly disagree

[ ] 22. How motivated were you to generate quality ideas?

Definitely not motivated 1----2----3----4----5 Very motivated

[ ] 23. If you had a chance to do the same kind of work in another student work group how would toy feel about moving to another group?

1 Would want very much to stay where I am
2 Would rather stay where I am than move
3 Would make no difference to me
4 Would rather move than stay where I am
5 Would want very much to move

[ ] 24. The participation in the discussion was:

Evenly distributed 1----2----3----4----5 Unevenly distributed

[ ] 25. After this group process, I learned to identify central issues in the area of object tracking technologies and their applications.

Strongly agree 1----2----3----4----5 Strongly disagree

[ ] 26. This group process encouraged me to express my ideas and opinions.
Not at all 1----2----3----4----5 Very much

[ ] 27. There were long periods during which the group did nothing.
Very much 1----2----3----4----5 Not at all

[ ] 28. 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

Very
Better About Worse Very
much than
the than much
better
most same most worse

[ ] 29. The way people get along together
1 2 3 4 5

[ ] 30. The way people work together
1 2 3 4 5

[ ] 31. The way people help each other
1 2 3 4 5

[ ] 32. This group process encouraged us to rethink ideas which had never been questioned before.
Not at all 1----2----3----4----5 Very much

[ ] 33. How would you describe your group's decision process?
Efficient 1----2----3----4----5 Inefficient

[ ] 34.
Coordinated 1----2----3----4----5 Uncoordinated

[ ] 35.
Fair 1----2----3----4----5 Unfair

[ ] 36.
Understandable 1----2----3----4----5 Confusing

[ ] 37.
Satisfying 1----2----3----4----5 Unsatisfying

[ ] 38. After this group process, my skill in critical thinking was increased.
Strongly agree 1----2----3----4----5 Strongly disagree

[ ] 39. Do you feel that you are really a part of your student work group?
1 Really a part of my group
2 Included in most ways
3 Included in some ways, but not in others
4 Don't feel I really belong too much
5 Don't feel I really belong at all

[ ] 40. This group process sought differing perspectives when solving problems.
Not at all 1----2----3----4----5 Very much

[ ] 41. After this group process, I learned a great deal of factual information about the subject area of object tracking technologies and their applications.
Strongly agree 1----2----3----4----5 Strongly disagree

[ ] 42. To what extent does your group's work reflect your inputs?
Not at all 1----2----3----4----5 Very great extent

[ ] 43. To what extent do you feel committed to the group's ideas and opinions?
Not at all 1----2----3----4----5 Very great extent

[ ] 44. To what extent do you feel personally responsible for the quality of the idea your group proposed?
Not at all 1----2----3----4----5 Very great extent

[ ] 45. After this group process, I became more interested in the subject area of object tracking technologies and their applications.
Strongly agree 1----2----3----4----5 Strongly disagree

The following is the list of applications your group came up with during the experiment. Please rate each application based on your own judgment. (You do not have to agree with the judgment of your group.)

Type the corresponding abbreviation;
CI: Critically Important
VI: Very Important
I: Important
SI: Slightly Important
IR: Irrelevant

G-I Tract Chemistry Monitor	
Criminal Beacon	
Mechanic	

Pocket-Size Doctor	
Security Pass Implant	
Smart Gun Implant	
Travel Log Tracker	
Order Fulfillment / Assembly Line Tracker	
Vital Sign Monitor Implant	
Chemical Process Instrumentation	
Embedded Serial Number ID	
Child or Pet Registration	
Car Driver Teller	
Security	
Home Security	
Stock Market Watcher	
Avoid Accidents & Lane Enforcement	
Automatic Vehicle Identification & Classification	
Tracking & Tagging Prisoners	
Air Flight Control	
Asset Tracking & Package Tracking	
Bio Medical Telemetry	
Space Shuttle Precision Docking System & Auto	

APPENDIX J

FREQUENCY TABLES FOR POST-EXPERIMENT QUESTIONNAIRE ITEMS

The following is the frequency tables for the post-experiment questionnaire items. The frequency data was also given by the experiment condition (structure and group size).

Q1. Did you feel any apprehension about generating your ideas?

(A lot of apprehension : No apprehension)

Mean = 3.69, Standard deviation = 1.20

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	8	4.19	22	11.52	49	25.65	46	24.08	66	34.55
Unstructured	11	5.95	24	12.97	46	24.86	42	22.70	62	33.51
All	19	5.05	46	12.23	95	25.27	88	23.40	128	34.04

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	2	1.59	22	17.46	29	23.02	26	20.63	47	37.30
Medium	17	6.80	24	9.60	66	26.40	62	24.80	81	32.40
All	19	5.05	46	12.23	95	25.27	88	23.40	128	34.04

Q2. This group process emphasized the value of questioning assumptions.
(Not at all : Very much)
Mean = 3.18, Standard deviation = 1.01

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	12	6.32	28	14.74	75	39.47	56	29.47	19	10.00
Unstructured	12	6.49	29	15.68	79	42.70	50	27.03	15	8.11
All	24	6.40	57	15.20	154	41.07	106	28.27	34	9.07

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	6	4.80	25	20.00	48	38.40	35	28.00	11	8.80
Medium	18	7.20	32	12.80	106	42.40	71	28.40	23	9.20
All	24	6.40	57	15.20	154	41.07	106	28.27	34	9.07

Q3. How much do you feel you participated in this task?
(A lot : Not much)
Mean = 2.23, Standard deviation = 1.17

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	66	34.55	63	32.98	32	16.75	24	12.57	6	3.14
Unstructured	58	31.35	61	32.97	31	16.76	24	12.97	11	5.95
All	124	32.98	124	32.98	63	16.76	48	12.77	17	4.52

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	50	39.68	41	32.54	15	11.90	14	11.11	6	4.76
Medium	74	29.60	83	33.20	48	19.20	34	13.60	11	4.40
All	124	32.98	124	32.98	63	16.76	48	12.77	17	4.52

Q4. How interesting was this group process?
(Very uninteresting : Very interesting)
Mean = 3.07, Standard deviation = 1.30

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	25	34.55	41	32.98	44	16.75	47	12.57	34	3.14
Unstructured	27	14.59	42	22.70	46	24.86	40	21.62	30	16.22
All	52	13.83	83	22.07	90	23.94	87	23.14	64	17.02

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	18	14.29	30	23.81	27	21.43	30	23.81	21	16.67
Medium	34	13.60	53	21.20	63	25.20	57	22.80	43	17.20
All	52	13.83	83	22.07	90	23.94	87	23.14	64	17.02

Q5. Only a few members dominated the group discussion.
(Strongly agree : Strongly disagree)
Mean = 3.14, Standard deviation = 1.21

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	13	6.81	39	20.42	55	28.80	49	25.65	35	18.32
Unstructured	23	12.43	44	23.78	53	28.65	40	21.62	25	13.51
All	36	9.57	83	22.07	108	28.72	89	23.67	60	15.96

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	14	11.11	29	23.02	27	21.43	31	24.60	25	19.84
Medium	22	8.80	54	21.60	81	32.40	58	23.20	35	14.00
All	36	9.57	83	22.07	108	28.72	89	23.67	60	15.96

Q6. How satisfied are you with the quality of the ideas your group proposed?
(Very satisfied : Very unsatisfied)
Mean = 2.28, Standard deviation = 1.14

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	60	31.41	54	28.27	40	20.94	27	14.14	10	5.24
Unstructured	50	27.17	74	40.22	38	20.65	13	7.07	9	4.89
All	110	29.33	128	34.13	78	20.80	40	10.67	19	5.07

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	41	32.54	42	33.33	27	21.43	11	8.73	5	3.97
Medium	69	27.71	86	34.54	51	20.48	29	11.65	14	5.62
All	110	29.33	128	34.13	78	20.80	40	10.67	19	5.07

Q7. How at ease were you during the idea generation process?
(Definitely not at ease : Very at ease)
Mean = 3.74, Standard deviation = 1.12

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	5	2.62	24	12.57	47	24.61	51	26.70	64	33.51
Unstructured	9	4.86	15	8.11	46	24.86	62	33.51	53	28.65
All	14	3.72	39	10.37	93	24.73	113	30.05	117	31.12

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	5	3.97	10	7.94	34	26.98	34	26.98	43	34.13
Medium	9	3.60	29	11.60	59	23.60	79	31.60	74	29.60
All	14	3.72	39	10.37	93	24.73	113	30.05	117	31.12

Q8. This group process sought differing perspectives when solving problems.
(Not at all : Very much)
Mean = 3.34, Standard deviation = 0.99

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	12	6.28	21	10.99	81	42.41	61	31.94	16	8.38
Unstructured	8	4.32	18	9.73	72	38.92	61	32.97	26	14.05
All	20	5.32	39	10.37	153	40.69	122	32.45	42	11.17

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	10	7.94	12	9.52	46	36.51	43	34.13	15	11.90
Medium	10	4.00	27	10.80	107	42.80	79	31.60	27	10.80
All	20	5.32	39	10.37	153	40.69	122	32.45	42	11.17

Q9. How stimulating did you find this group process?
(Not stimulating : Very stimulating)
Mean = 3.20, Standard deviation = 1.10

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	17	8.90	34	17.80	63	32.98	54	28.27	23	12.04
Unstructured	8	4.32	45	24.32	47	25.41	64	34.59	21	11.35
All	25	6.65	79	21.01	110	29.26	118	31.38	44	11.70

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	13	10.32	24	19.05	34	26.98	39	30.95	16	12.70
Medium	12	4.80	55	22.00	76	30.40	79	31.60	28	11.20
All	25	6.65	79	21.01	110	29.26	118	31.38	44	11.70

Q10. This group process got me to look at problems from many different angles
(Not at all : Very much)
Mean = 3.41, Standard deviation = 1.13

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	12	6.28	23	12.04	58	30.37	64	33.51	34	17.80
Unstructured	14	7.57	27	14.59	52	28.11	61	32.97	31	16.76
All	26	6.91	50	13.30	110	29.26	125	33.24	65	17.29

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	12	9.52	18	14.29	31	24.60	40	31.75	25	19.84
Medium	14	5.60	32	12.80	79	31.60	85	34.00	40	16.00
All	26	6.91	50	13.30	110	29.26	125	33.24	65	17.29

Q11. After this group process, I gained a good understanding of the subject area of object tracking technologies and their applications.
(Strongly agree : Strongly disagree)
Mean = 2.61, Standard deviation = 1.17

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	45	23.56	47	24.61	59	30.89	29	15.18	11	5.76
Unstructured	32	17.30	56	30.27	54	29.19	27	14.59	16	8.65
All	77	20.48	103	27.39	113	30.05	56	14.89	27	7.18

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	23	18.25	39	30.95	35	27.78	18	14.29	11	8.73
Medium	54	21.60	64	25.60	78	31.20	38	15.20	16	6.40
All	77	20.48	103	27.39	113	30.05	56	14.89	27	7.18

Q12. The group process uncovered valid alternatives that I had not considered.
(Strongly agree : Strongly disagree)
Mean = 2.38, Standard deviation = 1.13

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	47	24.61	66	34.55	51	26.70	19	9.95	8	4.19
Unstructured	46	25.00	63	34.24	39	21.20	25	13.59	11	5.98
All	93	24.80	129	34.40	90	24.00	44	11.73	19	5.07

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	28	22.22	38	30.16	31	24.60	21	16.67	8	6.35
Medium	65	26.10	91	36.55	59	23.69	23	9.24	11	4.42
All	93	24.80	129	34.40	90	24.00	44	11.73	19	5.07

Q13. This group process made me re-examine critical assumptions to question whether they are appropriate.
(Not at all : Very much)
Mean = 3.21, Standard deviation = 1.03

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	11	5.76	30	15.71	71	37.17	60	31.41	19	9.95
Unstructured	14	7.57	27	14.59	74	40.00	52	28.11	18	9.73
All	25	6.65	57	15.16	145	38.56	112	29.79	37	9.84

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	11	8.73	22	17.46	49	38.89	34	26.98	10	7.94
Medium	14	5.60	35	14.00	96	38.40	78	31.20	27	10.80
All	25	6.65	57	15.16	145	38.56	112	29.79	37	9.84

Q14. How confident are you in your group's decisions?
(Very confident : Very unconfident)
Mean = 2.33, Standard deviation = 1.20

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	53	27.75	58	30.37	37	19.37	27	14.14	16	8.38
Unstructured	59	31.89	64	34.59	33	17.84	22	11.89	7	3.78
All	112	29.79	122	32.45	70	18.62	49	13.03	23	6.12

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	46	36.51	37	29.37	19	15.08	14	11.11	10	7.94
Medium	66	26.40	85	34.00	51	20.40	35	14.00	13	5.20
All	112	29.79	122	32.45	70	18.62	49	13.03	23	6.12

Q15. Every member of the group did not have a job to do.
(Strongly agree : Strongly disagree)
Mean = 4.04, Standard deviation = 1.26

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	15	7.85	13	6.81	29	15.18	33	17.28	101	52.88
Unstructured	12	6.49	11	5.95	26	14.05	39	21.08	97	52.43
All	27	7.18	24	6.38	55	14.63	72	19.15	198	52.66

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	13	10.32	8	6.35	14	11.11	20	15.87	71	56.35
Medium	14	5.60	16	6.40	41	16.40	52	20.80	127	50.80
All	27	7.18	24	6.38	55	14.63	72	19.15	198	52.66

Q16. How satisfied with *your own performance* on this task?
(Very satisfied : Very unsatisfied)
Mean = 2.10, Standard deviation = 1.18

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	81	42.41	60	31.41	24	12.57	16	8.38	10	5.24
Unstructured	64	34.78	66	35.87	27	14.67	13	7.07	14	7.61
All	145	38.67	126	33.60	51	13.60	29	7.73	24	6.40

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	66	52.38	31	24.60	11	8.73	11	8.73	7	5.56
Medium	79	31.73	95	38.15	40	16.06	18	7.23	17	6.83
All	145	38.67	126	33.60	51	13.60	29	7.73	24	6.40

Q17. To what extent do you feel personally responsible for the quality of the idea your group proposed?
(Very great extent : Not at all)
Mean = 2.32, Standard deviation = 0.94

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	33	17.28	80	41.88	61	31.94	10	5.24	7	3.66
Unstructured	35	19.13	81	44.26	52	28.42	10	5.46	5	2.73
All	68	18.18	161	43.05	113	30.21	20	5.35	12	3.21

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	29	23.20	55	44.00	31	24.80	6	4.80	4	3.20
Medium	39	15.66	106	42.57	82	32.93	14	5.62	8	3.21
All	68	18.18	161	43.05	113	30.21	20	5.35	12	3.21

Q18. After this group process, I developed the ability to communicate clearly about the topic.
(Strongly agree : Strongly disagree)
Mean = 2.52, Standard deviation = 1.09

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	35	18.42	68	35.79	52	27.37	20	10.53	15	7.89
Unstructured	33	17.84	58	31.35	69	37.30	17	9.19	8	4.32
All	68	18.13	126	33.60	121	32.27	37	9.87	23	6.13

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	29	23.02	41	32.54	36	28.57	10	7.94	10	7.94
Medium	39	15.66	85	34.14	85	34.14	27	10.84	13	5.22
All	68	18.13	126	33.60	121	32.27	37	9.87	23	6.13

Q19. The work of the group was left to those who were considered most capable for the job
(Very much : Not at all)
Mean = 3.58, Standard deviation = 1.23

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	8	4.19	24	12.57	52	27.23	37	19.37	70	36.65
Unstructured	16	8.65	24	12.97	57	30.81	40	21.62	48	25.95
All	24	6.38	48	12.77	109	28.99	77	20.48	118	31.38

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	10	7.94	9	7.14	46	36.51	23	18.25	38	30.16
Medium	14	5.60	39	15.60	63	25.20	54	21.60	80	32.00
All	24	6.38	48	12.77	109	28.99	77	20.48	118	31.38

Q20. After this group process, I learned a great deal of factual information about the subject area of object tracking technologies and their applications.
(Strongly agree : Strongly disagree)
Mean = 2.63, Standard deviation = 1.17

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	37	19.37	54	28.27	56	29.32	28	14.66	16	8.38
Unstructured	36	19.46	51	27.57	56	30.27	32	17.30	10	5.41
All	73	19.41	105	27.93	112	29.79	60	15.96	26	6.91

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	24	19.05	39	30.95	35	27.78	19	15.08	9	7.14
Medium	49	19.60	66	26.40	77	30.80	41	16.40	17	6.80
All	73	19.41	105	27.93	112	29.79	60	15.96	26	6.91

Q21. To what extent do you feel committed to the group's decisions?
(Very great extent : Not at all)
Mean = 2.24, Standard deviation = 1.00

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	46	24.08	71	37.17	46	24.08	23	12.04	5	2.62
Unstructured	52	28.11	68	36.76	53	28.65	9	4.86	3	1.62
All	98	26.06	139	36.97	99	26.33	32	8.51	8	2.13

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	36	28.57	48	38.10	27	21.43	13	10.32	2	1.59
Medium	62	24.80	91	36.40	72	28.80	19	7.60	6	2.40
All	98	26.06	139	36.97	99	26.33	32	8.51	8	2.13

Q22. One person influenced the group's work more than the rest of the group.
(Strongly agree : Strongly disagree)
Mean = 3.39, Standard deviation = 1.23

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	10	5.24	30	15.71	49	25.65	45	23.56	57	29.84
Unstructured	14	7.57	45	24.32	51	27.57	41	22.16	34	18.38
All	24	6.38	75	19.95	100	26.60	86	22.87	91	24.20

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	12	9.52	29	23.02	30	23.81	27	21.43	28	22.22
Medium	12	4.80	46	18.40	70	28.00	59	23.60	63	25.20
All	24	6.38	75	19.95	100	26.60	86	22.87	91	24.20

Q23. How motivated were you to generate quality ideas?
(Definitely not motivated : Very motivated)
Mean = 3.64, Standard deviation = 1.06

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	5	2.62	25	13.09	46	24.08	78	40.84	37	19.37
Unstructured	9	4.86	20	10.81	38	20.54	76	41.08	42	22.70
All	14	3.72	45	11.97	84	22.34	154	40.96	79	21.01

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	7	5.56	11	8.73	28	22.22	48	38.10	32	25.40
Medium	7	2.80	34	13.60	56	22.40	106	42.40	47	18.80
All	14	3.72	45	11.97	84	22.34	154	40.96	79	21.01

Q24. If you had a chance to do the same kind of work in another student work group how would toy feel about moving to another group?
1 Would want very much to stay where I am
2 Would rather stay where I am than move
3 Would make no difference to me
4 Would rather move than stay where I am
5 Would want very much to move

Mean = 2.67, Standard deviation = 0.99

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	29	15.18	35	18.32	101	52.88	16	8.38	10	5.24
Unstructured	32	17.30	31	16.76	102	55.14	13	7.03	7	3.78
All	61	16.22	66	17.55	203	53.99	29	7.71	17	4.52

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	17	13.49	20	15.87	73	57.94	9	7.14	7	5.56
Medium	44	17.60	46	18.40	130	52.00	20	8.00	10	4.00
All	61	16.22	66	17.55	203	53.99	29	7.71	17	4.52

Q25. The participation in the discussion was:
(Evenly distributed : Unevenly distributed)
Mean = 2.48, Standard deviation = 1.22

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	52	27.23	54	28.27	48	25.13	24	12.57	13	6.81
Unstructured	48	25.95	43	23.24	55	29.73	25	13.51	14	7.57
All	100	26.60	97	25.80	103	27.39	49	13.03	27	7.18

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	40	31.75	27	21.43	28	22.22	23	18.25	8	6.35
Medium	60	24.00	70	28.00	75	30.00	26	10.40	19	7.60
All	100	26.60	97	25.80	103	27.39	49	13.03	27	7.18

Q26. After this group process, I learned to identify central issues in the area of object tracking technologies and their applications.
(Strongly agree : Strongly disagree)
Mean = 2.44, Standard deviation = 1.06

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	45	23.56	63	32.98	54	28.27	22	11.52	7	3.66
Unstructured	34	18.48	60	32.61	62	33.70	22	11.96	6	3.26
All	79	21.07	123	32.80	116	30.93	44	11.73	13	3.47

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	26	20.80	39	31.20	40	32.00	15	12.00	5	4.00
Medium	53	21.20	84	33.60	76	30.40	29	11.60	8	3.20
All	79	21.07	123	32.80	116	30.93	44	11.73	13	3.47

Q27. This group process encouraged me to express my ideas and opinions.
(Not at all : Very much)
Mean = 3.69, Standard deviation = 1.18

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	15	7.85	22	11.52	30	15.71	73	38.22	51	26.70
Unstructured	9	4.89	19	10.33	43	23.37	55	29.89	58	31.52
All	24	6.40	41	10.93	73	19.47	128	34.13	109	29.07

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	8	6.40	9	7.20	20	16.00	48	38.40	40	32.00
Medium	16	6.40	32	12.80	53	21.20	80	32.00	69	27.60
All	24	6.40	41	10.93	73	19.47	128	34.13	109	29.07

Q28. The group decision process made me critically reevaluate the validity of the alternatives that I had thought of.

(Strongly agree : Strongly disagree)

Mean = 2.72, Standard deviation = 1.05

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	19	10.00	75	39.47	63	33.16	21	11.05	12	6.32
Unstructured	24	12.97	47	25.41	68	36.76	34	18.38	12	6.49
All	43	11.47	122	32.53	131	34.93	55	14.67	24	6.40

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	14	11.11	45	35.71	40	31.75	19	15.08	8	6.35
Medium	29	11.65	77	30.92	91	36.55	36	14.46	16	6.43
All	43	11.47	122	32.53	131	34.93	55	14.67	24	6.40

Q29. The way people get along together

1. Very much better
2. Better than most
3. About the same
4. Worse than most
5. Very much worse

Mean = 2.33, Standard deviation = 0.86

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	31	16.23	70	36.65	82	42.93	7	3.66	1	0.52
Unstructured	39	21.08	65	35.14	67	36.22	13	7.03	1	0.54
All	70	18.62	135	35.90	149	39.63	20	5.32	2	0.53

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	21	16.67	44	34.92	48	38.10	11	8.73	2	1.59
Medium	49	19.60	91	36.40	101	40.40	9	3.60	0	0
All	70	18.62	135	35.90	149	39.63	20	5.32	2	0.53

Q30. The way people work together

1. Very much better
2. Better than most
3. About the same
4. Worse than most
5. Very much worse

Mean = 2.42, Standard deviation = 0.91

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	28	14.66	73	38.22	71	37.17	15	7.85	4	2.09
Unstructured	34	18.38	63	34.05	70	37.84	17	9.19	1	0.54
All	62	16.49	136	36.17	141	37.50	32	8.51	5	1.33

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	20	15.87	42	33.33	47	37.30	13	10.32	4	3.17
Medium	42	16.80	94	37.60	94	37.60	19	7.60	1	0.40
All	62	16.49	136	36.17	141	37.50	32	8.51	5	1.33

Q31. The way people help each other

1. Very much better
2. Better than most
3. About the same
4. Worse than most
5. Very much worse

Mean = 2.49, Standard deviation = 0.94

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	25	13.09	55	28.80	91	47.64	15	7.85	5	2.62
Unstructured	37	20.11	61	33.15	66	35.87	17	9.24	3	1.63
All	62	16.53	116	30.93	157	41.87	32	8.53	8	2.13

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	19	15.08	41	32.54	49	38.89	13	10.32	4	3.17
Medium	43	17.27	75	30.12	108	43.37	19	7.63	4	1.61
All	62	16.53	116	30.93	157	41.87	32	8.53	8	2.13

Q32. This group process encouraged us to rethink ideas which had never been questioned before.
(Not at all : Very much)
Mean = 3.22, Standard deviation = 1.06

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	11	5.76	30	15.71	71	37.17	65	34.03	14	7.33
Unstructured	14	7.57	33	17.84	60	32.43	53	28.65	25	13.51
All	25	6.65	63	16.76	131	34.84	118	31.38	39	10.37

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	12	9.52	17	13.49	46	36.51	41	32.54	10	7.94
Medium	13	5.20	46	18.40	85	34.00	77	30.80	29	11.60
All	25	6.65	63	16.76	131	34.84	118	31.38	39	10.37

Q33. How would you describe your group's decision process?
(Efficient : Inefficient)
Mean = 2.19, Standard deviation = 1.07

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	56	29.32	75	39.27	32	16.75	21	10.99	7	3.66
Unstructured	53	28.65	74	40.00	37	20.00	14	7.57	7	3.78
All	109	28.99	149	39.63	69	18.35	35	9.31	14	3.72

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	39	30.95	42	33.33	24	19.05	14	11.11	7	5.56
Medium	70	28.00	107	42.80	45	18.00	21	8.40	7	2.80
All	109	28.99	149	39.63	69	18.35	35	9.31	14	3.72

Q34. How would you describe your group's decision process?
(Coordinated : Uncoordinated)
Mean = 2.18, Standard deviation = 1.06

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	59	30.89	63	32.98	41	21.47	23	12.04	5	2.62
Unstructured	60	32.43	67	36.22	36	19.46	19	10.27	3	1.62
All	119	31.65	130	34.57	77	20.48	42	11.17	8	2.13

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	42	33.33	38	30.16	28	22.22	15	11.90	3	2.38
Medium	77	30.80	92	36.80	49	19.60	27	10.80	5	2.00
All	119	31.65	130	34.57	77	20.48	42	11.17	8	2.13

Q35. How would you describe your group's decision process?
(Fair : Unfair)
Mean = 1.95, Standard deviation = 0.94

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	71	37.17	64	33.51	42	21.99	11	5.76	3	1.57
Unstructured	73	39.46	71	38.38	32	17.30	8	4.32	1	0.54
All	144	38.30	135	35.90	74	19.68	19	5.05	4	1.06

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	50	39.68	42	33.33	27	21.43	6	4.76	1	0.79
Medium	94	37.60	93	37.20	47	18.80	13	5.20	3	1.20
All	144	38.30	135	35.90	74	19.68	19	5.05	4	1.06

Q36. How would you describe your group's decision process?
(Understandable : Confusing)
Mean = 2.09, Standard deviation = 1.05

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	59	30.89	63	32.98	45	23.56	15	7.85	9	4.71
Unstructured	69	37.50	72	39.13	31	16.85	7	3.80	5	2.72
All	128	34.13	135	36.00	76	20.27	22	5.87	14	3.73

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	42	33.60	44	35.20	28	22.40	6	4.80	5	4.00
Medium	86	34.40	91	36.40	48	19.20	16	6.40	9	3.60
All	128	34.13	135	36.00	76	20.27	22	5.87	14	3.73

Q37. How would you describe your group's decision process?
(Satisfying : Unsatisfying)
Mean = 2.24, Standard deviation = 1.02

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	45	23.68	65	34.21	57	30.00	18	9.47	5	2.63
Unstructured	54	29.35	74	20.22	34	18.48	19	10.33	3	1.63
All	99	26.47	139	37.17	91	24.33	37	9.89	8	2.14

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	34	27.42	42	33.87	31	25.00	12	9.68	5	4.03
Medium	65	26.00	97	38.80	60	24.00	25	10.00	3	1.20
All	99	26.47	139	37.17	91	24.33	37	9.89	8	2.14

Q38. After this group process, my skill in critical thinking was increased.
(Strongly agree : Strongly disagree)
Mean = 2.73, Standard deviation = 1.12

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	27	14.14	58	30.37	67	35.08	22	11.52	17	8.90
Unstructured	21	11.41	61	33.15	63	34.24	21	11.41	18	9.78
All	48	12.80	119	31.73	130	34.67	43	11.47	35	9.33

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	15	12.00	46	36.80	35	28.00	15	12.00	14	11.20
Medium	33	13.20	73	29.20	95	38.00	28	11.20	21	8.40
All	48	12.80	119	31.73	130	34.67	43	11.47	35	9.33

Q39. Do you feel that you are really a part of your student work group?
1 Really a part of my group
2 Included in most ways
3 Included in some ways, but not in others
4 Don't feel I really belong too much
5 Don't feel I really belong at all
Mean = 1.97, Standard deviation = 1.04

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	73	38.22	58	30.37	41	21.47	15	7.85	4	2.09
Unstructured	84	46.65	58	31.52	28	15.22	9	4.89	5	2.72
All	157	41.87	116	30.93	69	18.40	24	6.40	9	2.40

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	65	52.00	31	24.80	16	12.80	9	7.20	4	3.20
Medium	92	36.80	85	34.00	53	21.20	15	6.00	5	2.00
All	157	41.87	116	30.93	69	18.40	24	6.40	9	2.40

Q40. The work of the group was well divided among members.
(Strongly agree : Strongly disagree)
Mean = 2.08, Standard deviation = 1.14

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	83	43.46	49	25.65	34	17.80	20	10.47	5	2.62
Unstructured	74	40.22	45	24.46	38	20.65	21	11.41	6	3.26
All	157	41.87	94	25.07	72	19.20	41	10.93	11	2.93

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	58	46.40	28	22.40	24	19.20	13	10.40	2	1.60
Medium	99	39.60	66	26.40	48	19.20	28	11.20	9	3.60
All	157	41.87	94	25.07	72	19.20	41	10.93	11	2.93

Q41. This group process encouraged addressing problems by using reasoning and evidence, rather than unsupported opinion.
(Not at all : Very much)
Mean = 3.30, Standard deviation = 1.07

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	13	6.81	31	16.23	71	37.17	51	26.70	25	13.09
Unstructured	8	4.37	26	14.21	67	36.61	52	28.42	30	16.39
All	21	5.61	57	15.24	138	36.90	103	27.54	55	14.71

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	8	6.40	15	12.00	43	34.40	40	32.00	19	15.20
Medium	13	5.22	42	16.87	95	38.15	63	25.30	36	14.46
All	21	5.61	57	15.24	138	36.90	103	27.54	55	14.71

Q42. To what extent does your group's work reflect your inputs?
(Very great extent : Not at all)
Mean = 2.38, Standard deviation = 0.91

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Delphi	29	15.18	80	41.88	65	34.03	13	6.81	4	2.09
Unstructured	26	14.13	89	48.37	52	28.26	10	5.43	7	3.80
All	55	14.67	169	45.07	117	31.20	23	6.13	11	2.93

	1		2		3		4		5	
	N	%	N	%	N	%	N	%	N	%
Small	23	18.40	53	42.40	38	30.40	5	4.00	6	4.80
Medium	32	12.80	116	46.40	79	31.60	18	7.20	5	2.00
All	55	14.67	169	45.07	117	31.20	23	6.13	11	2.93

Q43. How satisfied are you with the *quantity* of the ideas your group proposed?
(Very satisfied : Very unsatisfied)
Mean = 2.09, Standard deviation = 1.11

	1		2		3		4		5	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Delphi	77	40.31	51	26.70	43	22.51	17	8.90	3	1.57
Unstructured	69	37.50	57	30.98	33	17.93	16	8.70	9	4.89
All	146	38.93	108	28.80	76	20.27	33	8.80	12	3.20

	1		2		3		4		5	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Small	45	36.00	39	31.20	23	18.40	12	9.60	6	4.80
Medium	101	40.40	69	27.60	53	21.20	21	8.40	6	2.40
All	146	38.93	108	28.80	76	20.27	33	8.80	12	3.20

Q44. During this group process, I frequently felt overloaded with information.
(Strongly agree : Strongly disagree)
Mean = 3.02, Standard deviation = 1.20

	1		2		3		4		5	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Delphi	20	10.47	48	25.13	59	30.89	37	19.37	27	14.14
Unstructured	22	11.96	38	20.65	63	34.24	36	19.57	25	13.59
All	42	11.20	86	22.93	122	32.53	73	19.47	52	13.87

	1		2		3		4		5	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Small	7	5.60	24	19.20	38	30.40	36	28.80	20	16.00
Medium	35	14.00	62	24.80	84	33.60	37	14.80	32	12.80
All	42	11.20	86	22.93	122	32.53	73	19.47	52	13.87

Q45. After this group process, I became more interested in the subject area of object tracking technologies and their applications.
(Strongly agree : Strongly disagree)
Mean = 2.67, Standard deviation = 1.18

	1		2		3		4		5	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Delphi	33	17.28	65	34.03	52	27.23	22	11.52	19	9.95
Unstructured	31	16.85	53	28.80	52	28.26	33	17.93	15	8.15
All	64	17.07	118	31.47	104	27.73	55	14.67	34	9.07

	1		2		3		4		5	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Small	21	16.80	39	31.20	34	27.20	17	13.60	14	11.20
Medium	43	17.20	79	31.60	70	28.00	38	15.20	20	8.00
All	64	17.07	118	31.47	104	27.73	55	14.67	34	9.07

APPENDIX K

INSTRUCTION AND EVALUATION FORM FOR IDEA EVALUATION

The following documents are the instruction and the evaluation form used in the expert judge idea evaluations.

Instruction for Judges

In this process, I want each of you to evaluate the ideas generated by the students who participated in my experiment. Please read the task which was given to the students.

All the unique ideas are summarized in the evaluation sheet. The first column of the evaluation sheet includes the subject to be tracked by the device. The second column of the evaluation sheet includes the title (e.g. **Tracking/Monitoring people**) and the description of the idea (e.g. Tracking the location of people any time, A device could be surgically implanted or installed in a wrist watch). The character "**T**" means the implementation of the idea requires special technology to be added.

You need to evaluate each idea in terms of two criteria:
Importance and **Creativity**.

Importance:	A:	Excellent or Outstanding Importance
	B+:	Very Important
	B:	Important
	C+:	Above Average Importance
	C:	Average Importance
	D:	Slightly Important
	F:	Useless or Not Important

Creativity:	A:	Exceptionally Creative
	B+:	Very Creative
	B:	Creative
	C+:	Above Average Creative
	C:	Average Creativity
	D:	Slightly Creative
	F:	Not Creative

It is expected that no more than 50% of the ideas will be evaluated with B, B+, and A.

Thank you very much for your effort!

Evaluation Form for Ideas

Evaluator:

Subjects	Description	I	C
Tracking/Monitoring			
People	Tracking/Monitoring people Tracking the location of people any time, A device could be surgically implanted or installed in a wrist watch		
People	Tracking people using a satellite (T) Tracking the location of people any time using a satellite		
Citizens for government	Monitoring citizens by a government To enforce citizens to follow the government rules, To enhance the level of security		
Alzheimer patients	Monitoring Alzheimer patients		
Mentally disturbed patients	Monitoring mentally disturbed patients		
Problem children	Monitoring problem children		
Hikers	Tracking hikers in field expedition Tracking the location of hikers, Making rescue easier in case of emergency, Providing entertainment by integrating with audio or video sensors		
Skiers	Tracking and monitoring skiers in ski slopes		
Female students	Tracking female students in campus To protect female students in a campus		
Athletes in competitions	Tracking locations of athletes in sporting competitions For example, in the marathon, the coaches, assistants, judges and audience will be able to track down where each runner is in the course.		

APPENDIX L

INSTRUCTION AND EVALUATION FORM FOR GROUP REPORT EVALUATION

The following documents are the instruction and the evaluation form used in the expert judge group report evaluations.

Instructions for Judges

In this process, I want each of you to evaluate the group reports generated by the students who participated in my experiment. Please read the task which was given to the students.

You need to evaluate each group report in terms of the following criteria:

1. Content of the report:

    - Quality of ideas: Whether or not the description of the ideas is clear, understandable and specific
    - Quality of positive consequences: Whether or not the positive consequences included in the report are clear, understandable and specific
    - Quality of negative consequences: Whether or not the negative consequences included in the report are clear, understandable and specific

2. Presentation format

    - Clarity and Completeness: Whether the report is clear and well organized and whether the report includes all the required contents

3. Overall quality of the report: Overall, how well the report was written

Please evaluate the report in terms of the following:

A: Excellent / Outstanding
B+: Very Good
B: Good
C+: Above Average
C: Average
D: Below Average
F: Very Poor

It is expected that no more than 50% of the ideas will be evaluated with B, B+, and A.

Thank you for your effort.

Evaluation Form of Group Report

Evaluator:

Report Number: 44

	Evaluation Criteria	Evaluation
Content of the report	Quality of ideas	
	Quality of positive consequences	
	Quality of negative consequences	
Presentation Format	Clarity and Completeness	
Overall	Overall quality of the report	

A: Excellent / Outstanding
B+: Very Good
B: Good
C+: Above Average
C: Average
D: Below Average
F: Very Poor

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