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Spontaneous Group Decision Making in Distributed Collaborative Learning:
A Quantitative Exploratory Study

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ABSTRACT

The paper reports on an exploratory study of student spontaneous group decision making (GDM) in distributed collaborative learning environments. Recordings of group meetings were collected from graduate students working on a database design project (in a library and information science program in California), from which group decision instances were extracted and formally coded for quantitative analysis. A follow-up survey was conducted to gather more information. The study finds that students are generally in favor of an unfacilitated and semi-structured GDM process, with group decisions typically made by consensus. A rigidly structured GDM process tends to be associated with poor group performance. GDM efficiency is an important predictor of the quality of final group products, and too much brainstorming may lead to difficulties. Students relying exclusively on text chatting tend to be unsure if their opinion was given equal attention, and those in underperforming groups are more doubtful about decision quality.

Keywords: *Collaborative Learning, Group Decision Making (GDM), Group Dynamics, Group Performances, Online Teaching*

INTRODUCTION

Current research on distributed collaborative learning has paid much attention to group dynamics and other factors affecting group performance (An, Kim, & Kim, 2008; Arora, Raisinghani, Leseane, & Thompson, 2011; Brindley, Blaschke, & Walti, 2009; Janssen, Erkens, Kirschner, & Kansellar, 2009; Lin, Chen, & Chen, 2011; Shen & Wu, 2011; Resta & Laferriere, 2007; So & Brush, 2008; Volet, Summers, & Thurman, 2009), but has overlooked spontaneous group decision making (GDM) to a large extent, in spite of one study (Reimann, Frerejean, & Thompson, 2009) that analyzed the temporal process of graduate students' GDM via text chatting. The lack of attention to students' spontaneous GDM in distributed collaborative learning prompted a call for increased investigation of this issue as a new research direction

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(Liu, 2010). In his pilot work, Liu established some key concepts and proposed a theoretical framework to guide future investigation. Findings from his preliminary survey indicate that spontaneous GDM is prevalent in distributed collaborative learning.

Although Liu's survey yielded some insights about spontaneous GDM in distributed collaborative learning, its findings are rather general and lack depth, specificity, and reliability, due to the subjective nature of the survey data. More research is needed to validate the survey findings, and more importantly, to gain an in-depth understanding of students' spontaneous GDM behaviors. An alternative research design with unobtrusive methods may be used to collect objective data about the process of spontaneous GDM as it unfolds.

In response, this paper reports on an exploratory study consisting of quantitative analyses of data extracted from the categorical coding of meeting recordings and a post-project questionnaire survey. The remaining content of this paper is organized as follows. First, it summarizes key points of previous research findings to provide a context. Then, it states the research problem and outlines specific research questions. After describing the research design and methods of data gathering, coding, and analysis, it presents statistical results and observations from in-depth group comparison. Finally, the paper concludes with a discussion of the research findings and future research directions.

LITERATURE REVIEW

The following paragraphs summarize major findings from previous studies about student spontaneous GDM activities to provide a context for this study. The reader is referred to Resta and Laferriere (2007) for a comprehensive review of literature on distributed collaborative learning, and to Liu (2010) for development of theoretical concepts related to student spontaneous GDM.

Some researchers alluded to student spontaneous GDM in their discussion of group processes and reported anecdotal observations. In problem-centered collaborative learning, especially where the learning task is to complete a project or solve a problem, students participate in frequent and intensive group interactions in real time to understand the problem, negotiate changes in their perception of the "problem", and revise solutions as their work progresses (McConnell, 2005). Their interactional activities typically involve defining the problem, identifying relevant parameters, brainstorming solutions, elaborating and evaluating suggested alternatives, selecting solutions, and negotiating a final decision (Kapur & Kinzer, 2007). Evidently, students working on collaborative learning tasks need to make all kinds of decisions as a group throughout the course of collaboration for learning, and spontaneous GDM is a prominent part of their interactive activities.

Liu (2010) argues that the nature and extent of spontaneous GDM in collaborative learning depends not only on whether the learning is content-centered or problem-centered, but also on what kind of problem serves as the learning task. He suspects that an ill-defined problem may spur more problem-related GDM activities. Furthermore, he categorizes students' GDM activities into three kinds: (1) negotiation of meeting schedules and group logistics, (2) identifying/deliberating options during the process of problem solving, and (3) reaching a final group decision as required by the task problem or scenario. According to him, spontaneous GDM is about the first two categories of interactional activities. The third category is task-imposed, and it has been extensively investigated in the traditional GDM research.

While some researchers suggest that groupware and group decision support systems help improve decision quality in collaborative learning (Benbunan-Fich, Hiltz, & Turoff, 2003; Fjermestad, 2004), others point out that the limitation of nonverbal communication cues (such as hand gesture and facial expression) and communication spontaneity in distributed environments increases the time needed to reach group consensus for decision making (Smith, 2005; Valaitis, Sword, Jones, & Hodges, 2005). Some earlier studies indicate that students seem to prefer synchronous communication for

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problem discussion, brainstorming, and group decisions making (Han & Hill, 2007; Johnson, Suriya, Yoon, Berrett, La Fleur, 2002; Kapur & Kinzer, 2007; Mattheos, Nattestad, Schittek, & Attstrom, 2001), in spite of some issues such as fast paces, feeling unheard, lack of peer response, and being overwhelmed by multiple "parallel" conversations (Valaitis et al., 2005). The noted issues are in particular reference to synchronous text chatting. This preference may be extended to and strengthened for audio teleconferencing which is more commonly used in distributed collaborating learning today.

Difficulties in student GDM have been noted in previous studies, either due to a lack of full participation (McConnell, 2005) or caused by group conflicts and dominance by a strong personality (Kapur & Kinzer, 2007). In the former case, a member who did not participate in the decision making process may question later the decision made by others in his/her absence and create havoc in the group. When personality dominance occurs, other students in the group suffer from anxiety about inclusion in the GDM process (McConnell, 2005; Wang, Sierra, & Folger, 2003).

Two alternative tactics have been employed by students to facilitate their GDM process, according to Johnson et al. (2002), Ochoa & Robinson (2005), and Smith (2005). One is to rotate the facilitator role among group members on regular basis, and the other is to have a "self-appointed" leader emerging in the group. An individual who feels strongly about the topic/project may step forward to pull the group together and emerge as a self-appointed gatekeeper, directing the discussion and deciding when consensus is reached. But the person may not have the skills to elicit productive participation from other group members, or even aggressively dominate the group's decision making process.

Lack of GDM skills among students is a common problem in collaborative learning (Duemer, Christopher, Hardin, Olibas, Rodgers, & Spiller, 2004; Ochoa & Robinson, 2005). When making group decisions, students often do not really go through the forming/brainstorming phase, and the first idea put forth tends to be taken up with little debate on its merits (Johnson et al., 2002; Kapur & Kinzer, 2007). Their decision making is more likely to be unstructured or semi-structured, and participants make decisions more frequently by implicit group consensus than by formal voting (Liu, 2010), in spite of some potential pitfalls such as social power influence (Knotek, 2003) and reinforcement of dominant idea (Lauzon, 2000). Training students on GDM skills or providing basic guidelines has been shown to have a positive impact on their learning outcomes as well as group processes (Katz & Rezaei, 1999; Prichard, Bizo, & Stratford, 2006).

RESEARCH PROBLEM AND QUESTIONS

As mentioned earlier, the main objective of this study was to validate Liu's (2010) survey findings and to gain an in-depth understanding of students' spontaneous GDM. The research problem is to discover group behaviors of students' spontaneous GDM in distributed collaborative learning environments by analyzing decision making instances in online meetings, focusing on spontaneous GDM in project-based collaborative learning.

Specifically, the research addresses these questions: (1) What approaches do students frequently employ in making group decisions while completing a collaborative learning project? What are their typical behaviors of spontaneous GDM in distributed collaborative learning? (2) What types of spontaneous group decisions do students make while working to complete a collaborative learning project? What distribution patterns of GDM instances can be identified in relation to group decision types? (3) Do media modes of group communication (text chatting vs. audio teleconferencing) have any impacts on group dynamics and the GDM process? (4) Does meeting facilitation and media mode have any influence on student GDM behaviors? (5) And finally, are students' spontaneous GDM behaviors related to their

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group performance of completing the learning task? If so, what are the differences in GDM behaviors and practices between underperforming and well performing groups?

METHODS

This study consists of two parts: analysis of meeting recordings and survey of group members after project completion. The data were collected in the spring semester of 2010 from graduate students taking an introductory course on information retrieval (in two sections but taught as one class) in a library and information science program in California.

Project, Tasks, and Group Formation

Students taking the introductory course were required to complete a group project in the first half of the semester. The group project was to design a miniature entity-based search system for a hypothetical collection of non-information objects in order to learn the basic principles of 'attributes-based' indexing. The assignment instructions specified what was to be produced and submitted, but included nothing on how to proceed with the group project. Therefore, the project was unstructured, necessitating spontaneous GDM by students in each stage.

The group project included the following specific tasks: 1) choosing a collection of non-information items, 2) identifying users' searching needs, 3) determining entity attributes, 4) developing record structure and indexing rules, 5) implementing the design using the InMagic DB/Textworks® software, and 6) writing a project report. The collection could be hypothetical as long as it was familiar to and understandable by an average person, but could not be comprised of items with title and author, and the choice needed to be approved by the instructor. The group project report had to include documentation of all design decisions with justifications for each as well as InMagic® textbase files as an appendix.

At the start of the semester, students (totaling 49 with two sections combined) were randomly assigned into groups of an optimal size of five. Ten groups were formed, of which one had four students, due to the section having only 24 enrollments. To help students with group initiation, one member in each group was randomly designated to initiate the first group meeting, and students were told that this individual should not be expected to automatically assume a leadership role.

Recordings of Group Meetings

Students were instructed to conduct and record all their group meetings in Elluminate *Live*!® (a web-based teleconferencing system). The system offers rich functions for online instruction and collaboration, and has been used in the school for real-time class meetings and student group activities. They were told that the rationale of having them record group meetings in the system was to enable later investigation of any group difficulty and lack of participation if necessary. This explanation served in a way as pretext to ensure capturing as much group activities as possible while minimizing the risk of altering group dynamics.

After students completed the group project, an email was sent to the whole class asking for voluntary submission of meeting recordings for research. The email explicitly stated the research focus and promised that their recordings would be used for this research only, with strict protection of privacy and confidentiality. It was also made clear that a group might submit their meeting recordings only after every member had agreed and signed the informed consent form. Students were also advised to submit either all or none of their recordings, since the research intention was to investigate spontaneous GDM throughout the whole project lifespan. Those agreeing to participate were asked to complete a follow-up questionnaire survey. No incentive or reward for participation was offered.

In the end, five (out of ten) groups agreed to participate, and 21 segments of recordings (one per meeting) were collected, all valid for

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Table 1. Descriptive statistics of group meeting recordings

Groups	Group Size	Meetings (N)	Meeting length		# of GDM instances		Mean instance length
			Mean	STD	Mean	STD	
A	5	3	68.00	9.6437	16.33	2.0817	4.16
B	4	6	60.17	15.7787	18.33	13.4263	3.28
C	5	5	155.20	89.0573	23.00	8.6891	6.75
D	5	4	62.50	28.1247	17.75	7.5000	3.52
E	5	3	86.33	52.9182	29.33	13.0512	2.94
Overall	24	21	88.10	60.0690	20.62	10.2395	4.27

analysis. Their group size, frequency of meetings, mean meeting length in minutes, and average count of decision instances per meeting are given in Table 1, with groups renumbered for protection of identity. Of each group, the number of meetings is defined as the number of recordings submitted, and scheduling of meetings was done by students themselves as they deemed necessary. The length of a meeting, in minutes, was determined by time marks of start and end voice signals on the recording timeline. Similarly, the time length of decision instance was determined by markers placed on the recording timeline when coding GDM instances, as explained below.

Coding of Recordings

With submitted links, recordings of group meetings were extracted from the server and downloaded for offline playing as video clips. The recordings included text chat, audio conversation, and occasional text display on the whiteboard. After screening for and noting any use of the whiteboard, the video recordings were then rendered into portable formats, with text chatting turned into text files, and audio into mp3 files for ease of manipulation.

An assistant was hired to help code the recordings. The assistant was trained by the author on the coding protocol and instructed to analyze each recording in two rounds, first to note meeting-level characteristics such as meeting length, member absence, etc., and then to code specific GDM instances. Each GDM instance (defined as a discrete group decision) was coded directly in a SPSS data file, in terms of categorical variables predefined to characterize GDM behaviors. The pre-defined variables were: 1) instance length, 2) decision nature, 3) facilitation, 4) voting, 5) audio/text, 6) brainstorming, 7) deliberation, 8) personality dominance, 9) number of alternatives considered, and 10) decision making method (voting vs. consensus seeking). Initial coding results were checked for accuracy and consistency.

The Survey

An online questionnaire survey of participants was conducted after project completion to gather additional information about their collaborative learning and GDM experiences. The survey was implemented as part of the class site in the instruction management system (Angel®), but made accessible only to those five groups of students who agreed unanimously to participate in the research. Responses were not anonymous since the system automatically tracked participation, which allowed mapping of individual responses into project groups and therefore to their meeting recordings. The five participating groups (one of four and the others of five) had 24 members in total, of which four dropped the class after completing the group project due to personal circumstances and consequently lost access to the survey. Of the remaining 20 members, 16 responded to the survey, yielding

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a response rate of 66.7% relative to the total number of participants in the research.

The questionnaire (included as Appendix) was adopted from a previous study (Liu, 2010) with some necessary adjustment, consisting of six sections. The first section was for gathering demographic data, and the last section included three open-ended questions. The remaining sections were each comprised of a sequence of five-point Likert scale questions to assess the participants' collaborative learning and GDM experiences.

Data Analysis

The data extracted from the recordings were analyzed in two steps, first at the level of the meeting and then at the level of the GDM instance. The meeting-level analysis focused on general characteristics of the meeting dynamics (such as facilitation and personality dominance), and the instance-level analysis focused on GDM behaviors. The survey data were analyzed by computing percentages of categorized responses and means of Likert scale points (integers 1-5), correlated to group-level statistics when necessary, but not to specific meetings or GDM instances.

Student works for the group project were evaluated by the author, and the grading was reviewed by another instructor teaching the same course for validation. Evaluation criteria included: 1) proper choice of a collection of objects, 2) completeness of attribute identification, 3) specificity of cataloging rules, 4) implementation of InMagic® textbase, and 5) writing quality of project report. Letter grades were assigned based on overall assessment of group performance according to these five criteria. Two groups were graded as "excellent" (A), and the other three groups as "good" (A-), "average" (B), and "poor" (C) correspondingly (as shown later in Table 2). Comparative analyses between the "excellent/good" and "average/poor" groups were conducted to identify potential differences at the levels of meeting dynamics and GDM instances as well as in self-reported subjective experience.

In all cases, cross tabulation was computed for meaningful pairs of categorical variables for potential correlation, with statistical significance determined by chi-square analysis. Where Pearson's chi-square test was inappropriate due to violation of its assumption, Fisher's exact test was used for 2X2 tables, and Likelihood Ratio (LR) test for larger tables (Campbell, 2007; Cochran, 1952, 1954; Yates, Moor, & McCabe, 1999). A one-way ANOVA was conducted for mean comparison of numeric variables between project groups, with Duncan as post hoc test to identify outstanding group means. A single sample t-test was used for determining statistical significance of overall means with all project groups combined, and Spearman's rho was calculated for correlation between the grading of group performance and the mean time length of decision instances.

Table 2. Overall characteristics of group meetings for GDM

Characteristics		Groups			
	A	B	C	D	E
Facilitation	No	No	All	No	No
Structured	semi	semi	fully	semi	semi
Audio conferencing	2.0%	No	70.4%	97.2%	94.3%
Text chatting	100.0%	100%	95.7%	71.8%	44.3%
Google Docs	No	No	47.9%	39.4%	No
Whiteboard	Yes	Yes	Yes	Yes	Yes
Grading	Good	Excellent	Poor	Average	Excellent

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All data analyses were done using the IBM® SPSS20 software.

RESULTS

The results of data analyses are reported in four parts, first an overview, second analysis of general correlation patterns, then comparison between well-performing and underperforming groups, and finally a summary of survey responses.

Overview

The five student groups are comparable in group composition, with no statistically significant difference between groups in demographics (age, ethnicity, gender, level of computer skills, English proficiency) and past experience of teleconferencing and online GDM. Except for Group E, all other groups had one member dropping the class after completing the project due to personal circumstances. Further, no statistically significant difference was found between groups in points earned by individual students toward their final grades.

Of the 16 participants who responded to the survey, 14 were female and 2 male, 11 white and 5 Hispanic. In terms of age, 5 were in the range of 20-29, 9 of 30-39, and 2 of 40-49. Although 14 were native English speakers, only 11 considered their English language proficiency as excellent. Nine participants rated their computer/Internet proficiency as "high", 2 as "expert", and 5 as "average". Eight of them had experience with online collaborative learning, and 14 had experience with face-to-face GDM, but only 6 had online GDM experience.

The general characteristics of GDM meetings are summarized in Table 2. Of the five groups included in this study, two (A and B) made group decisions almost exclusively by text chatting, and audio conferencing was used by Group A sporadically for exchanging pleasantries. Only Group C had all their meetings fully structured, with 84.3% facilitated by the group leader and 15.7% by a volunteering member. All the other groups' meetings were not facilitated but semi-structured, suggesting a general preference of the laissez-faire approach. Google Docs was used by two groups (C and D) for GDM, and both produced relatively poor final products.

Across the board, about 1/4 - 1/3 of GDM instances involved explicit effort of brainstorming for alternatives. None of the groups ever attempted systematic ranking of options being considered, and in most cases they did not vote formally. Instead, decisions were made by seeking implicit or explicit group consensus (i.e., silence meaning "no objection" vs. spoken agreement). The whiteboard was occasionally used for GDM. The percentage distribution of decision instances by group behavioral types is given in Table 3, with the top scores marked with italics and the second highest scores with dashed underline.

Three groups (B, C, and D) had two or three instances where the decision was made by one group member for all, and they seemed to have a noticeable issue of personality dominance in group discussion. Nevertheless, most members in each group (on average 3.64 relative to the group size of 5 and in one case of 4) participated actively. Member absence was common in Group A, with almost one absence in every GDM instance, though not always by the same individual. Absences were less common in groups D and E, and did not occur at all in groups B and C. This observation suggests that students in online classes may indeed have difficulty scheduling synchronous meetings for making group decisions.

The number of options considered per group decision averages to 2.36, which is statistically representative ($t = -0.84$, $p=0.933$). Group-specific and overall means of alternative counts, persons speaking up before deciding, and members absent from meetings are listed in Table 4, with standard deviation underneath. While within-group variations (indicated by standard deviation) are relatively big, between-group differences are quite small, though statistically significant. With Duncan post hoc analysis, outstanding means are identified and underlined.

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Table 3. Behavioral characteristics of GDM instances by group (%)

GDM Behaviors		Groups				Overall (N=433)
	A (n=49)	B (n=110)	C (n=115)	D (n=71)	E (n=88)	
Brainstorming for options	**28.6**	21.8	*28.7*	19.7	25.0	24.7
Deliberating before deciding	42.9	50.0	**58.3**	50.7	*60.2*	53.6
Ranking alternatives	0.0	0.0	0.0	0.0	0.0	0.0
By formal voting	0.0	0.9	*2.6*	0.0	**2.3**	1.4
By explicit consensus	59.2	50.9	**80.0**	60.6	*85.2*	68.1
By implicit consensus	**40.8**	*44.5*	15.7	36.6	12.5	28.6
One member deciding for all	0.0	**2.7**	1.7	*2.8*	0.0	1.6
Personality dominance	0.0	**11.8**	*19.1*	8.5	3.4	10.2
Use of whiteboard	14.3	14.5	**18.3**	11.3	*20.5*	16.2

The percentage distribution of group decision types is given in Table 5, with the top percentage scores marked with italics and the second highest scores with dashed underline. Taking 10% as the cutoff point, four major types of group decisions are identified. In descending order, they are: (1) revisiting a decision/solution, (2) group coordination, (3) problem definition and understanding, and (4) assignment of mini-task responsibilities. These are followed by determination of project scope and identification of specific/mini tasks. But the percentage scores of these two decision types vary greatly from group to group.

Correlational Patterns

To understand whether meeting-level characteristics have any influence on student GDM behaviors, correlation analyses were conducted on meaningful pairs of related variables. Statistically significant results are reported below.

Facilitation appears to be a major factor influencing student GDM behaviors. When meetings were unfacilitated and semi-structured, students were more likely to make group decisions by seeking for consensus (97.4%) either explicitly or implicitly (N=317, X^2 = 14.142, p=0.003). Furthermore, students were more likely to deliberate when the meeting was facilitated by the group leader (64.9%) and

Table 4. Group comparison of counts of alternatives, speakers & absent members

Numeric Variable	Groups (mean/STD)					Overall (N=433)	F	p
	A (n=49)	B (n=110)	C (n=115)	D (n=71)	E (n=88)			
Alternatives considered	*2.67* 1.449	*2.11* 0.513	2.43 1.352	2.44 1.079	2.32 0.904	2.36 1.079	2.825	0.025
Persons speaking up	3.24 0.969	3.47 0.809	*4.30* 1.002	3.41 0.969	3.41 0.942	3.64 1.015	19.952	<0.001
Members absent	*0.92* 0.812	0 0	0 0	0.63 0.485	0.68 0.468	0.35 0.540	93.555	

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Table 5. Types of group decisions being made (%)

Nature of Group Decision		Groups					Overall
		A	B	C	D	E	
Logistics	Meeting date/time	*6.1*	**3.6**	1.7	0.0	2.3	2.5
	Group coordination	**16.3**	9.1	*20.9*	14.1	12.5	14.5
Project	Overall direction	**8.2**	1.8	2.6	*8.5*	1.1	3.7
	Choosing application/problem	*6.1*	0.9	0.9	2.8	**3.4**	2.3
	Planning stages	**2.0**	0.9	0.0	*4.2*	0.0	1.2
	Determining project scope	*10.2*	6.4	**9.6**	8.5	9.1	8.5
Mini-tasks	Identifying specific/mini tasks	**10.2**	1.8	7.0	2.8	*13.6*	6.7
	Assigning responsibilities	8.2	*10.9*	**10.4**	9.9	10.2	10.2
	Establishing timeline/milestones	2.0	1.8	*4.3*	**4.2**	3.4	3.2
Problem	Defining and understanding	10.2	*20.0*	**13.9**	5.6	0.0	10.9
	Choosing approach to solving	0.0	1.8	**2.6**	0.0	*4.5*	2.1
	Developing a solution	2.0	**3.6**	0.0	0.0	*4.5*	2.1
Revisiting/re-evaluating a decision/solution		18.4	**37.3**	26.1	*39.4*	33.0	31.6

least likely when led by a volunteer (22.2%). Personality dominance was more likely to happen in meetings not facilitated (48.8%) or facilitated by the group leader (39.5%) (N=43, $X^2 = 16.505$, $p<0.001$).

Students were more likely to use audio when deliberating (61%, N=231, $X^2=8.826$, $p=0.003$), and they did not make heavy use of the whiteboard (24.7%). But when they did use the whiteboard, it was most likely for deliberation as well (81.4%, N=70, $X^2=26.242$, $p<0.001$).

Brainstorming was found to be correlated strongly with deliberation (94.4%, N=107, $X^2= 95.724$, $p<0.001$). As expected, students considered more alternatives when a group decision was made with brainstorming, and the means of alternative counts per decision instance (2.94 with brainstorming and 2.16 without) were found to be significantly different ($t=6.833$, $p<0.001$).

Survey Results

Participant responses to all questions in Part B (perception of general group coherence) and Part E (system support), as well as to most in Part C (effectiveness of collaborative learning) and Part D (GDM effectiveness), are homogeneously positive, with no statistically significant differences found between groups by the one-way ANOVA test. Nevertheless, significant differences were found between groups in reference to six questions, three in Part C and the other three in Part D. Table 6 summarizes group means of integers (1-5) representing Likert scale points (1 for "strongly agree" and 5 for "strongly disagree") and standard deviation, with outstanding means italicized. Table 6 includes only those six questions of which statistically significant differences were found among groups, to keep the table size manageable.

Generally speaking, better performing groups found it more agreeable that their collaborative learning was of high quality (C7), that all members were motivated to learn (C11), and that they contributed their share to the group's final product (C12). The pattern is evidently noticeable if focusing on Group E in

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Table 6. Group means of Likert-scale uestions with significant difference (mean/STD)

Survey Questions		Groups				F	p
	A n=4	B n=3	C n=3	D n=2	E n=4		
C7. Learning from collaboration online was of the highest quality.	*3.33* 0.577	2.00 0.000	2.33 0.577	2.50 0.707	*1.50* 0.577	5.382	0.014
C11. All members in my group were motivated to learn.	*3.67* 0.577	2.33 0.577	2.00 1.000	2.50 0.707	*1.50* 0.577	4.397	0.026
C12. All contributed his/her share to the group products.	*4.33* 0.577	2.67 1.155	2.00 1.000	3.00 1.414	*1.25* 0.500	3.652	0.044
D3. My opinion was given equal attention.	*3.00* 1.414	2.67 0.577	2.00 0.000	1.50 0.707	*1.00* 0.000	3.749	0.037
D16. Made quick decisions without compromising the quality.	2.25 0.500	1.67 0.577	*3.33* 0.577	2.00 0.000	2.00 0.000	6.490	0.006
D23. Some decisions were made by emailing.	*1.00* 0.000	2.00 0.000	2.00 0.000	*3.00* 1.414	1.75 0.500	5.688	0.010

comparison to the others. Their responses to questions C11 and C12 seem to be supported by the earlier finding from analysis of GDM instances. Specifically, most group members (3.64 per instance) spoke up during the decision making process, and on average 2.36 alternatives were considered before finally deciding on the issue in question.

In regard to GDM experience, students in groups A and B (both relying exclusively on text chatting) were more unsure if their opinion was given equal attention. Those in Group C were clearly hesitant about their group decision quality, while all other better performing groups were confident that they made good group decisions efficiently.

All students (except for Group D) admitted that they made some decisions by exchanging external emails. Private emails exchanged among group members were not collected in this study, and therefore it is impossible to tell how their GDM by emailing might be different and how external emailing might have influenced their GMD behaviors in real time.

Finally, it is important to note that most participants believed that providing training and instruction would have made their collaborative learning and GDM more effective.

Comparative Analysis

To find out how spontaneous GDM impacts student collaborative learning, it is necessary to identify differences in behavioral patterns between well performing and underperforming groups by comparative analysis. However, such comparison turns out to be not as straightforward as it appears. Two groups (C and D) performed relatively poorly in completing the project task, and groups B and E were most successful. One may be tempted to compare these two pairs (each as a combined set) on all variables in a conglomerated way. However, such a conglomerated comparison is inappropriate, because the groups in each pair aren't really compatible in meeting process structure and use of communication media. An alternative approach is to compare two groups (one well performing and the other relatively underperforming) that are similar in terms of their meeting structure/process and use of communication media.

Group A ("good") vs. Group B ("excellent"). Both Group A and Group B relied almost exclusively on text chatting for GDM, and neither used Google Docs®, as shown in the meeting recordings. Although their average meeting lengths and numbers of decision instances per meeting were in the same range,

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Group A's meetings were slightly longer (by about 8 minutes) and with fewer decision instances per meeting, which suggests that Group A took more time to make a group decision. However, Group B was smaller in size, had twice as many meetings, and made more than twice as many group decisions in total as Group A did (110 vs. 49). It seems that the smaller group size might have made it easier to familiarize with each other, to coordinate group activities, and to manage the logistics, which led to a greater efficiency of GDM.

Group A had more decision instances with brainstorming, considered more alternatives, made decisions more by explicit consensus, and never by formal voting. They had no instance of personality dominance. In contrast, Group B was more likely to deliberate and had a greater percentage of decisions made by implicit consensus. Occasionally, Group B voted formally and had one member deciding for all. In fact, personality dominance happened in almost 12% of Group B's decision making activities, at a significantly higher frequency (LR=10.087, p=0.001).

Judging from the percentage distribution of instances by decision types as shown in Table 5, Group A made more decisions in regard to setting meeting dates, coordinating group activities, determining overall project direction and scope, and identifying specific tasks. In comparison, Group B made significantly more decisions about assigning task responsibilities, problem definition and understanding, and revisiting decisions already made (LR=22.698, p=0.03).

Group D ("average") vs. Group E ("excellent"). In spite of similar preference of audio conferencing, Group D made significantly greater use of text chatting (N=159, X^2= 12.109, p=0.001) and had a lower absence rate. Their meetings were significantly shorter (t=-18.374, p<0.001), with fewer group decisions made per meeting (see Table 1), and it took them about half a minute longer on average to make a decision (3.52 vs. 2.94 minutes per decision instance). Although personality dominance happened in both cases, Group D had this issue more often and even had one member deciding for all occasionally.

In contrast, Group E made decisions occasionally by formal voting, more frequently by explicit consensus (N=159, LR=18.771, p<0.001), and never had one member deciding for all. They seemed to brainstorm and deliberate more frequently and also made more use of the whiteboard.

In terms of decisions types, Group D had greater percentages of decision instances for problem definition and understanding, group coordination, identification of project direction, planning project stages, establishing timelines, and revisiting decisions already made. But it had fewer decision instances for choosing a suitable application problem and identifying mini tasks, and none for choosing a problem-solving approach (N=159, LR=37.210, p<0.001).

Group C ("poor") vs. others. It is also interesting to examine Group C in comparison to all other groups since it is the only group that had all its meetings facilitated and fully structured, and more importantly, it received the lowest grade. More than 70% of its GDM activities involved use of both text chatting and audio conferencing, and the rest were by text chatting only.

Its average meeting length is almost twice as long as that of the other groups. Although its mean count of decision instances per meeting is greater, it took this group almost 3 minutes longer to make a decision (see Table 1). In fact, there seems to be a correlation between the grading of group performance and the mean time length of decision instances. Specifically, we have A>B and C>D>E. In other words, the greater the mean time length of a decision instance, the lower the grade. The correlation is relatively strong (Spearman's rho=0.458, p=0.134), though not statistically significant due to the small sample size (N=21).

The inverse correlation between the amount of time taken to make a group decision and group performance suggests potential difficulties the group had in reaching group consensus for decision making, which affected not only the efficiency but also the effectiveness of GDM,

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and ultimately the quality of group decisions and group performance. Closer examination of Group C seems to confirm this suspicion, as summarized below.

A significantly higher percentage of Group C's decisions were made by seeking explicit consensus. It also has the greatest mean (4.3) of number of persons speaking up during the decision making process. Although this shows strong motivation and a high level of active participation in the group, it may also be interpreted as indication of having too many different opinions voiced when trying to make a group decision. The group also had the highest percentage of decision instances with brainstorming, and the second highest percentage with deliberation, which may be interpreted as an indicator of this issue as well. Furthermore, the group had the highest percentage of personality dominance, and more frequent occurrence of personality dominance certainly made the situation even worse. When there were too many different and potentially conflicting opinions voiced, it understandably became more difficult and took longer for them to reach a group consensus. This is confirmed to some extent by the survey finding that students in this group were mostly hesitant as to whether they made quick group decisions without compromising decision quality.

It is interesting to note that Group C had the highest percentage of meeting time spent on making decisions for coordinating group activities and establishing timeline and milestones of mini tasks. It also had higher percentages of decision instances for determining project scope, assigning responsibilities, problem definition, and choosing an approach to problem solving. On the other hand, it had no decision instance for planning project stages and solution development. Taken in the context of observations made in the previous paragraph, all these findings about Group C indicate that this group had difficulties with making group decisions in all fronts and aspects of completing the group project, which explains why they ended up having the poorest performance.

DISCUSSION

The analysis of meeting recordings clearly shows a general preference of the laissez-faire approach among students, favoring an unfacilitated and semi-structured process with consensus seeking, and rarely employing a systematic ranking of alternatives with formal voting, which is consistent with previous research findings (Liu, 2010; Valaitis et al., 2005). The only group having all its GDM activities facilitated and structured also produced the poorest group work. It seems that rigid structuring and facilitation of meetings might have made the group more vulnerable to personality dominance, leading to compromised decision quality. However, it may be too simplistic to conclude that facilitation of the GDM process leads to poor decision quality and poor learning outcomes, since other factors may be in play here.

With text chatting and audio teleconferencing both available, students are able to use either or both for GDM. Students may choose to carry out their GDM activities exclusively by text chatting, especially when their computers are not equipped with a headset; in such cases, they are likely unsure if their opinions are given equal attention. Where audio teleconferencing is used dominantly, students tend to use text chatting as a supplementary means for commenting while one member is talking, and they also seem more likely to make group decisions by seeking for explicit consensus. Nevertheless, the media mode (text vs. audio) seems to have little impact on student performance of collaborative learning.

GDM efficiency (measured as the time length of the GDM instance) is found to be correlated to group performance and outcome of distributed collaborative learning. The longer it takes a group to make decisions on average, the poorer the quality of its final group product, which indirectly suggests less effective collaborative learning. This finding may seem not making sense at first look. Intuitively, one may expect that a group taking more time to decide would have made their decisions more carefully

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-- with more consideration and deliberation. This should have led to group decisions of better quality, which in turn should have yielded a better final product. This seemingly illogical finding may be explained by taking an alternative view of group dynamics. Since most of their decisions were made by seeking for group consensus, underperforming groups might simply have had more different (and potentially conflicting) opinions voiced, more alternatives to consider, and thus greater difficulty resolving their differences to reach a consensus. This alternative explanation is supported by the results from comparative analysis of Group C in relation to the other groups.

An additional factor potentially explaining the counterintuitive finding stated above is the overdoing of brainstorming. Johnson et al. (2002) and Kapur and Kinzer (2007) complained that students often did not go through the forming/brainstorming phase when making group decisions. Contrary to their observation, this study found that too much brainstorming could be counterproductive, confirming previous observations by some researchers (Orlitzky & Kirokawa, 2001; Reimann, Frerejean, & Thompson, 2009). All three underperforming groups (A, C, and D) considered significantly more alternatives, but none did systematic ranking. Having too many alternatives to consider but without systematic evaluation could make the GDM process counterproductive. It may easily cause information overload and make the deliberation stage chaotic, leading to greater difficulty in reaching consensus.

Although with a relatively low frequency, personality dominance does occur in student GDM, more likely when the meeting is facilitated by a group leader, and seemingly in partial correlation to the practice of having one group member deciding for all. In fact, it happened with the highest frequency in the group with poorest performance (C), but also with a higher frequency in one better performing group (B). Thus, the signal is mixed. The practice of having one member deciding for all may be sometimes to the group's advantage if the deciding member is more knowledgeable about the task in hand. Hence, the issue of leadership quality needs to be considered.

The study reveals that students spend a significant amount of GDM efforts (about one third of decision instances) revisiting and re-evaluating a group decision already made, confirming Reimann, Frerejean, and Thompson's (2009) finding of a frequent looping in students' GDM process. Actually, better performing groups tend to do even more redressing of previously decided matters. Their revisiting of group decisions was not because of the challenging and changing of group rules by an absent member (McConnell, 2005), but a result of the group's changed perception of the situation and later realization of poor decision quality. This finding seems to suggest that students tend to make group decisions rather hastily in their initial attempts, only to find out later that these decisions need to be redressed with more careful consideration. This explanation seems even more plausible in view of the facts that better performing groups took shorter time to make a decision on average and that none of the groups attempted to systematically rank all identified alternatives before deciding on one.

The types of group decisions students make while completing a project fall into four major categories: 1) logistics management, 2) project management, 3) mini-task identification and assignment, and 4) problem solving; their frequency distributions vary a great deal. Student GDM activities are more centered on determining project scope, defining and understanding the problem, coordinating group work, and assigning responsibilities of mini-tasks. In contrast, they tend to spend minimal time choosing appropriate problem-solving approaches and developing solutions, although such activities (in addition to problem analysis) are more likely to affect their group decision quality and performance (Graham, Papa, & McPherson, 1997; Hirokawa & Salazar, 1999). This is especially the case for underperforming groups.

The research findings outlined above point to students' lack of effective GDM skills and needs for related guidance and training, as

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noted by other researchers (Duemer et al., 2004; Ochoa & Robinson, 2005). They are positive about their experiences of online collaborative learning in general and of GDM in particular, and confident about their GDM skills. But at the same time, they generally agree that guidance and training on GDM skills would have made their group decision making more effective and their collaborative learning experience more rewarding.

CONCLUSION

This exploratory study supplements and validates Liu's (2000) survey findings by analyzing GDM instances captured in recordings of student group meetings and participants' responses to a follow-up survey. Besides identifying general patterns of student GDM behaviors, it compares underperforming groups against well-performing ones to reveal differences in group dynamics and GDM behaviors that potentially contribute to the effectiveness of distributed collaborative learning.

The research findings summarized in the previous section should be taken with consideration of limitations of the study. First, students' email exchanges for GDM were not included in the data gathering, because of privacy concerns and logistic difficulty. Except for one group, all the students admitted making group decisions outside of the Elluminate *Live*!® system via emails, albeit the percentage of such instances was extremely small (less than 3%). Second, the study was limited to GDM activities in project-centered collaborative learning, and participants were all from the same graduate course, working to complete the same group assignment. This limitation prevented the study from yielding insights about potential dependencies between GDM behaviors and collaborative learning tasks and subject domains.

In spite of the aforementioned limitations, this study produced valuable findings from analysis of real-time GDM activities in a distributed collaborative learning environment, providing preliminary empirical evidences for refining the theory and developing hypotheses. Future research needs to identify significant factors influencing students' spontaneous GDM behaviors and to increase the understanding of dependencies between spontaneous GDM and learning tasks and subject domains, as well as to understand how external emailing prior to and during a GDM meeting may influence the group's dynamics and decision making behaviors in the real-time meeting. Students' spontaneous GDM via asynchronous emailing remains to be investigated. Extensive research is also needed to develop intervention strategies and tactics to encourage constructive practices of spontaneous GDM for increased effectiveness of collaborative learning in distributed environments.

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APPENDIX

Survey Questionnaire

Part A. Demographics

A1: Age: 20-29, 30-39, 40-49, 50-59, 60-69, 70-79, >=80.
A2: Gender.
A3: Native English speaker? If not, please indicate your level of oral communication skill in English.
A4: Please estimate your level of Internet/computer proficiency: Poor / Low / Average / High / Expert .
A5: What is your predominant ethnic background: White / African American / American Indian and Pacific Islander /Asian / Hispanic / Multiracial / Other.
A6: Have you had any experience of collaborating online before this class?
A7: Have you had any experience of teleconferencing on the Internet before this class?
A8: Have you had any experience of making decisions as a group onsite before this class?
A9: Have you had any experience of making decisions as a group in distributed online environment before this class?
[Note: Questions in Parts B through E are of five-point Likert scale of "strongly agree", "agree", "unsure", "disagree", and "strongly disagree".]

Part B. Group Perception

B1: I feel similar to others in my project group.
B2: I feel being ignored by other members in my group most of the time.
B3: Our project group is cohesive.
B4: I feel being excluded by other members in my group.
B5: I feel I have much to offer to the group in regard to the class project.
B6: I am a cooperative participant in the project group.
B7: I often feel I am a useless member of the project group.
B8: If I am going to do another group project, I'll be happy to work in the same group again.
B9: Had I been given a choice, I would have chosen to work with at least one of my group members anyway.
B10: I respect this group, even though I may not agree with it all the time.
B11: In my opinion, my group members (as a whole) would act similarly in a **similar** situation.
B12: In my opinion, my group members (as a whole) would act similarly in a **different** situation.
B13: In our group, we were able to resolve differences/conflicts with respect and reason.
B14: Our group dynamics would be different if not being recorded in the Elluminate *Live*! system.
B15: I would act pretty much the same if the meetings were not recorded in the Elluminate *Live*! system.

Part C. Reflection on collaborative learning experience

C1: I was able to learn from group discussions.
C2: I was stimulated to do additional readings or research on topics/issues discussed in group meetings.
C3: Group discussions assisted me in understanding other points of view.

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C4: As a result of my experience with this group project, I would like to take more courses with similar online collaboration components.
C5: The group project was a useful learning experience.
C6: I put in a great deal of effort to learn Internet/computer skills to collaborate on the group project.
C7: My level of learning from online collaboration was of the highest quality.
C8: Collaborative learning experience in online environment is better than in a face-to-face environment.
C9: I felt part of a learning community in my group.
C10: I actively exchanged my ideas with group members.
C11: All members in my group are motivated to learn.
C12: All members in my group contributed his/her share to the group products.
C13: I was able to develop new skills and knowledge from other members in my group.
C14: I was able to develop problem solving skills through peer collaboration in this class.
C15: Collaborative learning in my group was effective.
C16: Collaborative learning in my group was time consuming.
C17: Overall, I am satisfied with my collaborative learning experience in this class.
C18: Overall, I find my experience of collaboratively working on the group project satisfactory.

Part D. Reflection on group decision experience

D1: My inputs were valued in the group's decision making.
D2: I felt that I was not given an equal chance to speak when making a group decision.
D3: I felt that my opinion wasn't given equal attention when making a group decision.
D4: I felt the other group members decided everything.
D5: I felt I was able to influence how decisions were made in our group.
D6: I felt I had control over the course of the game.
D7: Oftentimes I just played along with whatever others decide to do.
D8: If everyone listened to me, we would have made better/wiser choices.
D9: When trying to decide on something, we spent way too much time going back and forth.
D10: We should have discussed/deliberated more before making a group decision.
D11: We could have avoided some mistakes if not having to please everyone.
D12: We could have avoided some mistakes if not being dominated by a certain group member.
D13: I am glad that we had one really knowledgeable member deciding things for us.
D14: At least once, I managed to significantly change others' views on issues being decided on.
D15: Group discussion often changed my mind/stand on the issue being decided on.
D16: As a group, we made quick decisions without compromising the quality.
D17: As a group, we made good decisions in general.
D18: I believe our group members demonstrated good skills of group decision making.
D19: We would have made better decisions as a group if we were given some training on how to make group decisions more effectively.
D20: Our meetings would be more productive if we were given some training on how to make group decisions more effectively.
D21: We would have made better decisions as a group if we were given some guidelines and instructions on how to make group decisions more effectively.
D22: Our meetings would be more productive if we were given some guidelines and instructions on how to make group decisions more effectively.

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D23: In our group, some decisions on the group project were made outside of the Elluminate *Live*! system.
D24: We check with each other via email before meeting in the Elluminate *Live*! system to make a decision.

Part E. Technological Support

E1: The school's Elluminate *Live*! system provided sufficient support for our group's decision making.
E2: The system should automatically compile and list items contributed by participants.
E3: The system should automatically compute rankings of option items based on members' voting.
E4: When brainstorming, the system should not allow us to see who said what.
E5: More system support is needed for making group decisions in a well-structured manner.
E6: Our group would have produced better work had the system provided better support of group decision making.

Part F. Open Ended Questions/Comments

F1: Please enter below any comments or observations you like to share about your collaborative learning experience in this class.
F2: Please enter below any comments or observations you like to share about your group's decision making activities in this class.
F3: Please enter below any comments or feedback about this survey or the research project in general.

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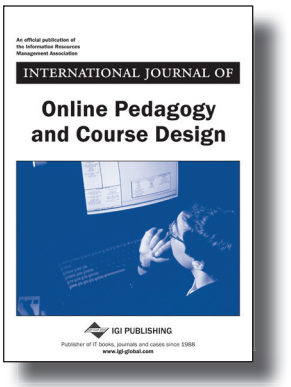

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The mission of the *International Journal of Online Pedagogy and Course Design* (IJOPCD) is to provide a platform for the latest research, analysis, and development of online education, effective online teaching methods, and course design. IJOPCD covers the pedagogical design aspects of science education and computing education, as well as courses supported by educational technologies. Targeting academic researchers and educators who work in the field, this journal focuses on the importance of developments in online course design and teaching methods to improve teachers' teaching and students' learning. Researchers are encouraged to submit cross-disciplinary, high-quality syntheses that are interesting, beneficial, and apprehensible to all those interested in or teaching science and related disciplines.

COVERAGE:

Topics to be discussed in this journal include (but are not limited to) the following:

- Adoption of e-learning
- Best practices in computing education
- Best practices in science education
- Blended learning
- Computer-mediated communication
- E-learning
- Emerging technologies
- Evaluation of learning technology systems
- Evaluation of online learning effects
- Learning management systems
- Multimedia and interactive learning systems
- Online course design
- Online learners' behavior
- Pedagogy and teaching with technology
- Virtual reality environments
- Web-based teaching methods

All submissions should be emailed to:
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Ideas for special theme issues may be submitted to the Editors-in-Chief.

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