Assessing Cognitive Change in a Computer-Supported Collaborative Decision-Making Environment

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This study examined the impact of two collaborative technologies and a priming agent upon communication complexity and learning style in a group decision-making context. Findings revealed that communication complexity was significantly greater in groups using a group support system compared to groups using a simple chat system, suggesting that characteristics of the group support system served to structure discourse among group members. Further, group members using a priming agent experienced a significant shift in learning style, as measured by the Kolb Learning Styles Inventory, indicating that cognitive processing in information technology supported collaborative environments may be improved with appropriately designed and deployed support documentation.

In the past two decades a variety of disciplines have participated in envisioning, testing, and developing information technology tools specifically designed to address human collaboration at work, commonly known as Computer Supported Collaborative Work (CSCW) systems. Early research in CSCW, taking a decidedly techno-centric orientation, focused primarily on collaborative tool development. Later research extended to decision quality, participant reaction, and impact of specific collaborative tools on group effectiveness.

While these studies provide substantive contributions toward the development of CSCW products to meet specific goals, they do not produce the broad and transcendent themes necessary to guide future research. Essential to thematic development is establishing standardized units of measurement that can serve to compare various collaborative technologies. Regardless of factors that serve to differentiate one collaborative event from another such as intent, mode, media, synchronicity or asynchronicity, participant demographics, problem characteristics, or environmental influences, independent properties of CSCW must be identified. Since human communication occurs in all collaborative contexts, it is reasonable to suggest that standardized measures are based upon some aspect of human communication. The properties of CSCW that impact human communication are, therefore, foundational to research in the field.

This study considers the role of language in transferring cognitive structures from the individual contribution level to the group level of processing during collaboration. On a general level, language facilitates the sharing of meaning. More specifically, language carries with it perceptual frameworks which, when broadly accepted by group members, serve to organize both understanding and ensuing action. In this manner, language functions as a structural transfer agent. Such structural transfer has qualities that both reflect one's understanding of observable phenomena and help shape the nature of ensuing behavior. Communicators assimilate new structures into existing mental frameworks and accommodate framework variations that may

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accompany suggestions by fellow group members. It is important to know whether and how CSCW systems impact structural transfer.

Purpose of the Study

This study examines the impact of two forms of collaborative technology on the transfer of cognitive structure in a group decision-making context. Specifically, this study attempts to determine: (a) if a relationship exists between frequency of verb structures in transcripts of a group problem-solving activity and the use of either a collaborative technology or use of a priming agent; and (b) whether learning is affected, in the form of a shift in learning style, by the kind of collaborative technology employed or by priming agents.

Research Questions

The following research questions guided the research:

1. Does structure-laden language impact learning, reflected in significant score changes on the Kolb Learning Styles Instrument (LSI)?
2. Does use of a collaborative technology within group discussion impact the structuring of group discourse?
3. Does the presence of an organization chart (priming agent) as a reference item in group discussions impact the level of discourse in such a way as to enhance structuring of group discourse?

Answers to these questions may suggest specific ways organizational members can use technology as a learning tool to support productive group work. Further, information derived from this study may provide new focus to CSCW research by introducing new theoretical themes, addressing dependent and independent variables not previously addressed in CSCW research.

Review of Literature

The predominant theoretical foundation for this study is based upon a linguistic theory proposed by Taylor and Van Every (2000) tracing structural transfer through the grammatical construction of conversation. When grammatical structure is formulated in the utterance of language and transferred to a receiver, the receiver of the communication employs this structure to facilitate interpretation. Taylor and Van Every's (2000) theory suggests that complex grammatical constructions, called *ditransitive verb structures*, serve to transfer not only simple meanings, but also relationships among persons and objects. In short, language structures contain inherently organizational qualities.

For example, the sentence "Make sure the quality assurance manager orders additional samples from the line inspectors." involves two levels of organizational action. The first level of action is contained in the phrase "make sure" and requires action from the individual to whom the directive is issued. The second level of action is contained in the phrase "orders additional samples" and requires action of the quality assurance manager. What makes the overall structure ditransitive is that the quality assurance manager's action is contained within and contingent upon the primary verb phrase "make sure." This action within action is inherently organizational. These grammatical structures can serve as dependent variables to measure complexity in mediated and/or primed group decision-making contexts.

Several studies consider the impact of information technology mediation on communication. Hewett (1998) used student writing groups to analyze communication patterns under two conditions: oral communication among peers and oral plus computer supported communication among peers. Findings revealed that oral talk focused on more abstract, global idea development, while computer-mediated communication focused more on concrete writing issues and group management. These findings also suggest that computer-mediated communication shaped both the nature of the discussion and the revisions of the written end product. Scott (1997) studied the use of computer-mediated communication to augment traditional classroom activities and determined that a combination of face-to-face and computer-mediated discussion resulted in self-reported learning increases and higher grades. Plowman (1994) explored the experiences of writing students

in a collaborative writing activity. Subjects used chalkboard, paper, and a computer to co-write a response to an essay question. Interaction was recorded and analyzed to determine the role of written text in the process of conceiving and writing a final answer. Plowman determined that text-based communication alone compared poorly with the combination of text-based communication and talking in terms of cognitive support.

Organizational learning theory also provides a foundation for this study. Building on the work of Senge (1990), Kim (1993) proposed an integrated approach to shared mental models. The transfer of mental models from one organizational member to another indicates learning has occurred. The mental model is the basis for organizational action when broadly accepted and implemented across the organization. The mode of model transfer is language, and Senge suggests using organizational learning laboratories to serve as the site for group discussion. Learning laboratories promote problem-based dialog, place the responsibility for thinking and problem-solving on the participant, promote application of previous experience, require active participation, and place participants in a naturally-occurring problem context.

Several recent studies suggest a link between technological mediation and cognitive development, highlighting the potential for examining the impact of CSCW on mental model transfer. For example, the impact of system presence on cognition may help explain sub-optimal group level decision performance. Flor and Hutchins (1993) argue that use of system-based tools and procedures in software design produces system-level cognitive properties that are distinct from those of individual programmers. Software developers are affected by software design methodology in a manner beyond their own cognitive processing patterns compared to working without the methodology. The product of this human-system enterprise results in a form of distributed cognition.

Salomon (1990) considered cognitive effects both with and of computer technology. He found that end-users could accomplish tasks while working with the technology that could not be achieved without it and postulated that completion of computer supported cognitive tasks may build cognitive skills that remain after interaction with CSCW has ended. Shlechter (1990) assigned experimental subjects in groups around one computer for computer-based training (CBT) and compared completion time, learning difficulty, and resistance to forgetting with a control group consisting of individuals using the same CBT at one computer alone. Grouped participants were not encouraged to collaborate. While learning achievement did not differ, collaborative groups experienced greater learning efficiency as determined by reduced training time, decreased proctor support, and amount of content retained.

Shedletsky (1993) discussed the nature of change implicit in the use of computer-mediated communication and why change occurs in terms of learning theory. Using an email-based interpersonal (conversational) approach, he identified four levels of learning that may help participants learn: response, situation, transsituation, and transcencence. He reasoned that when participants switch from natural to computer-mediated communication, they are more likely to shift from lower level (response and situation) learning to higher levels (transsituation and transcencence). Morrissey (1997) considered the use of groupware in case-based management education to overcome logistical problems commonly associated with geographically dispersed learning groups, to enhance the quality of case solutions, and to enhance the processes groups undertake in developing case solutions. Results indicated that groups using groupware showed improved quality of case preparation and analysis over other groups.

Hilmer and Dennis (2000) experimented with techniques to improve attention and integration of information among learners. Groupware categorizing tools were used to require participants to read every comment produced through the group activity and to categorize each comment as either important or not important. By categorizing based upon importance, researchers hypothesized that attention and categorization behaviors would enhance individual member integration of concepts. Those participants who did consider and evaluate the importance of every submission integrated more information, which improved decision quality.

Kwok, Ma, and Vogel (2000) compared traditional facilitation methods with the use of a group support system. They theorized that

intentional and meaningful subject feedback in a collaborative learning group promotes assimilation of new information, which in turn stimulates learner interaction and promotes accommodation of new information to restructure mental models. Results of analysis determined that using both group support systems and content facilitation contributed to both the assimilation and accommodation processes. They conjectured that the fundamental principles of learning are facilitated by the unique features of collaborative learning tools and by an anonymous content facilitator who does not display dominance over the group, but instead provides knowledgeable support for meaningful learning.

Citing the recent increase in research of groupware applications in classroom learning, Khalifa, Kwok, and Davison (2001) determined that process facilitation, employing a less structured and open facilitation style, is more influential than content facilitation with respect to knowledge acquisition. Software features in a groupware collaboration system were used to set process and content restrictiveness levels for the experiment. While content facilitation restrictiveness made no apparent impact on learning, results suggested process restrictiveness significantly inhibited learning.

Methodology

A randomized factorial design, crossing two modes of communication with two levels of structural primer, was used to reveal whether differences exist among treatment and control groups in pretest and posttest scores on the LSI and in frequency of ditransitive verb structure. Significant differences on dependent measures along the lines of communication mode and existence of a primer will indicate that structural transfer may be facilitated or prohibited by using a collaborative technology, either with or without a priming device.

Students from three course sections of a business communications course were identified as potential subjects for experiments. The three sections met on different days, at different times, and were led by different instructors. To control for these factors, subjects from each course section were randomly assigned to one of three groups, identified as Oral, Chat, and GSS. Oral groups participated in the study by undertaking the task orally, without computer-mediated support. Chat groups undertook the task using a simple chat-based software product on a networked computer system. GSS groups undertook the task using a groupware product on the same networked computer system.

Task

Subjects in the GSS, Chat, and Oral groups were assigned to read a case description illustrating a business problem, devise a plan to solve the problem, and write the plan for presentation to a fictitious company president. The Lazy-Days Manufacturing Case (Johnson & Johnson, 1991) provides a rich context for discussion, debate, and planning. The case problem lacks evidence of a single correct solution, which helped ensure the text of the case does not bias subjects toward a specific plan. The case problem is brief and somewhat complex, but was not beyond the subjects' experience level.

The case supported the research objective of identifying incidents of structural transfer in several ways. First, all discussion among group members was recorded, providing a document for analysis. Second, since there is no evidence for a single best solution, subjects' perceptions and recommendations became the basis for devising the plan. This allowed sufficient opportunity for imposition of a subject-originated mental model as opposed to the discovery of an existing mental model within the text of the case. Third, the case was realistic, providing subjects with a problem they may encounter on some level in the future. This factor enhanced the likelihood that subjects would more fully engage in the problem-solving process, providing opportunity for this level of involvement to be reflected in posttest results, should changes in cognitive processing actually occur. Fourth, the case was not media-dependent. This factor ensured that the mode of content delivery did not bias subject responses. All problem-solving group members received the same one-sheet photocopy of the case. Fifth, discussion time for the case was 35 minutes, a time period sufficient to generate ideas, discuss the ideas, and develop a plan. This factor reduced the potential for fatigue.

Subjects

Undergraduate students in four sections of a Business Communications course at a small southeastern university (N = 106) served as the subjects for the study. Subjects represented all areas of study within the bachelor of business administration program, including management, marketing, real estate, accounting, finance, economics, and information systems. Two subjects represented non-business disciplines. Subjects enrolled in the course to meet program requirements. The majority of subjects were in their third year of study, having completed the pre-business core and several courses in their respective areas of emphasis. The business communication course addressed a wide range of communication issues related to general business functions. During the course, subjects undertook learning projects on topics such as communication theory, intercultural communication, grammar and syntax, report writing, letter writing, job application and resume writing, electronic communication, and persuasive writing.

Procedures

Subjects were randomly assigned to an Oral, Chat, or GSS group. Copies of the case study were distributed to all participants, and copies of an organization chart were randomly distributed to half of the participants in each discussion group. After a reading of the case aloud by the facilitator, Oral subjects discussed the case orally and the other groups began typing to discuss the case. During the case the facilitator prompted Chat participants to change to the next phase of the discussion. The GroupSystems group followed the system-based agenda requiring brainstorming, voting, commenting, and outlining a plan. All groups followed the same general structure for the discussion: brainstorming, discussion, and writing. At the end of 35 minutes groups were asked to end their work and present their plans.

Instrumentation

To conduct the ditransitive structure frequency count, unedited end-user text files were filtered using the AMALGAM linguistic analysis software program that sifts individual lines of text and reports grammatically coded parts of speech. In this case, the coding identified verbs. The verb report was used to count verbs indicative of ditransitive grammatical structure and to produce a measure of language structuring.

Kolb's (1984) theory of experiential learning was used as a basis for measuring change in learning. The most recent version of the Kolb Learning Style Instrument (LSI) was used for pretest and posttest purposes and was provided by David Kolb via publisher Hay/McBer (personal communication, March 13, 2001). Post-experimental analysis of ditransitive verb structure frequencies and treatment level (GSS, Chat) might indicate the conditions under which individuals leverage collaborative technologies to support transfer of knowledge to the group level.

Independent Variables

The main independent variable was the mode of interaction used by group members to develop a solution to the case problem. The two modes of collaboration utilized were a fully deployed group support system (GSS) and a chat system. The group using the GSS used a hardware system composed of networked computers and a collaboration decision-making software package (GroupSystems™). Subjects heard the case and interacted with group members with the software. Human facilitation was minimized, ensuring that guidance came from the subjects and the inherent features of the tools employed by the software. Subject decision-making activities were organized by the collaboration software in accordance with specific tools applied at key points in the group discussion. Tools applied in this case included brainstorming, voting, commenting, and outlining. Group members entered comments into the system simultaneously and read any previous contributions by scrolling through the tool screen. The discussion was organized into time periods associated with each tool. For example, a period of ten minutes was allocated to brainstorming.

The group using the chat system used a hardware system composed of the same networked computer system and a chat software package

(VyChat™). The chat software did not provide collaborative tools such as those provided by the group support system but provided subjects with a blank screen for text composition and similar to the group support tool above, permitted simultaneous contribution. Participants also had the capability to scroll through the text and review all previous contributions. Group members were directed to each phase of the discussion on the same schedule as those in the GSS groups.

The Oral groups used no computer mediation to discuss the case and produce a recommendation. While these groups were minimally facilitated, the facilitator suggested a decision-making structure identical to that used by GSS and Chat groups prior to starting the discussion. Faulty recording equipment produced an inaudible transcript of these discussions, which eliminated Oral groups from the structural analysis portion of the study. Pretest and posttest measures on the LSI were available for analysis.

Another independent variable was the priming agent used to suggest structure. An organization chart was randomly distributed with the one sheet case study to half of the case study participants in each group. The chart referenced organizational entities typically found in small manufacturing firms. The purpose of the chart was to suggest that solutions to the case could involve actors or entities from various parts of the organization. Use of the chart in each group was warranted to control for group-related intervening variables.

Dependent Variables and Data Collection Techniques

Dependent variables included the pretest and posttest scores on the LSI and frequency reports of ditransitive structure produced by group discourse. Subjects were pretested approximately two weeks prior to undertaking the case study. Immediately following the case study the posttest was administered. In the pretest, subjects were asked to complete the instrument in the normal fashion, reflecting upon general tendencies in their learning experiences. For the posttest, however, subjects were asked to reflect upon their immediately preceding experience, the case study discussion. Differences in pretest and posttest scores were used to assess whether changes in learning style occurred during the case activity.

Findings

Analysis of data proceeded along four paths: (a) the effect of medium on the amount of communication and language complexity; (b) the effect of primer on the amount of communication and language complexity; (c) the effect of medium on learning style; and (d) the effect of primer on learning style. Treatment group assignment (medium) and exposure to a priming agent (primer) served as independent variables. Grammatical and syntactical frequencies and coefficients derived from pre- and posttest LSI administrations comprised the dependent variables. Quantified data sets were analyzed using the SPSS statistical analysis software.

Effect of Medium on Amount of Communication and Language Complexity

Independent samples t-tests on the medium variable were conducted to identify and analyze specific indicators of structural transfer on the communication level attributable to individual group members: number of words, number of verbs, ratio of verbs to words, number of utterances, number of organizational ditransitive verb (ODTV) structure occurrences, and ratio of ODTV structure occurrences to utterances. Statistical summaries are found in Tables 1 and 2.

Chat groups produced significantly more words, $t(32) = 3.25$, $p = .002$, and verbs, $t(28) = 3.59$, $p = .001$, than did their GSS counterparts.

Table 1: Differences in Amount and Type of Communication (Words & Verbs) by Medium

	Medium	N	Mean	Std. Deviation	Std. Error Mean	Effect Size
Words	CHAT	18	301.33	138.95	32.75	1.12
	GSS	16	166.31	96.41	24.10	
Verbs	CHAT	18	53.17	24.52	5.78	1.20
	GSS	16	28.50	14.82	3.71	
Verb Rate	CHAT	18	.1791	.0239	.0056	.09
	GSS	16	.1766	.0299	.0074	

However, the ratio of verbs to words between Chat and GSS groups did not differ significantly, t(32) = .265, p = .795. Chat groups produced significantly more utterances, t(18) = 5.516, p = .0005, than did their GSS counterparts, but did not produce differences in the frequency of organizational ditransitive verb structure frequency, t(32) = .523, p = .594. The ratio of ODTV frequency to utterance between Chat and GSS groups did differ significantly, t(32) = -8.172, p = .0005.

Table 2: Differences in Amount and Type (Contribution & Linguistic Structure Complexity) of Communication by Medium

	Medium	N	Mean	Std. Deviation	Std. Error Mean	Effect Size
Utterances	CHAT	18	36.56	22.35	5.27	1.73
	GSS	16	7.25	2.74	.6862	
ODTV freq.	CHAT	18	4.61	3.24	.7633	.1799
	GSS	16	4.13	1.93	.4820	
ODTV Rate	CHAT	18	.1388	.1083	.0255	2.81
	GSS	16	.5959	.2079	.0519	

Chat group members produced more words and verbs than did GSS members. But proportionately, the simple verb to word ratio did not differ. Chat group members contributed more frequently than did their GSS counterparts. GSS group members were more likely to make contributions representing the ODTV (more complex, ditransitive) structure than were Chat group members. No other differences were indicated in the data.

Effect of Priming Agent on Amount of Communication and Language Complexity

Independent samples t-tests on the primer variable considered whether the presence or absence of the organization chart was a factor with respect to number of words, number of verbs, ratio of verbs to words, number of utterances, number of organizational ditransitive verb (ODTV) structure occurrences, and ratio of ODTV structure occurrences to utterances. Results are found in Tables 3 and 4.

Subjects without an organization chart produced slightly but not significantly more words, t(32) = .099, p = .922, than did their primed counterparts. Further, the presence of a priming agent did not produce differences in the verb frequency, t(32) = -.042, p = .967. Also, the ratio of verb frequency to words between primed and non-primed groups did not differ significantly, t(25) = -.596, p = .557. Primed groups produced no more utterances, t(32) = .259, p = .799, than did their non-primed counterparts. The frequency of organizational ditransitive verb structure frequency did not differ between the two groups, t(32) = -.141, p = .888. The ratio of ODTV frequency to utterance between primed and non-primed groups did not differ, t(32) = -.951, p = .345. Primer appeared to have no effect on the number of words produced, number of verbs, the ratio of verbs to

Table 3: Differences in Amount and Type of Communication (Words & Verbs) by Primer

	Primer	N	Mean	Std. Deviation	Std. Error Mean	Effect Size
Words	No Chart	16	240.31	146.10	36.53	.0341
	Chart	18	235.56	133.21	31.40	
Verbs	No Chart	16	41.38	25.49	6.37	.0144
	Chart	18	41.72	22.91	5.40	
Verb Rate	No Chart	16	.1749	.0321	.0080	.2127
	Chart	18	.1806	.0208	.0049	

Table 4: Differences in Amount and Type of Communication (Words & Verbs) by Primer

	Primer	N	Mean	Std. Deviation	Std. Error Mean	Effect Size
Utterances	No Chart	16	23.81	23.53	5.88	.0883
	Chart	18	21.83	21.07	4.97	
ODTV freq.	No Chart	16	4.31	2.73	.6814	.0486
	Chart	18	4.44	2.71	.6377	
ODTV Rate	No Chart	16	.3051	.2641	.0660	.3292
	Chart	18	.3973	.2970	.0700	

words, the number of utterances, the occurrence of organizational ditransitive structure, or ODTV rate.

Effect of Media on Learning Style

In addition to the linguistically based results presented above, the data were also explored for changes in cognitive function during the treatment. The LSI served as pre- and posttest measures to identify and characterize possible changes in cognitive processing when undertaking the case study. Pre- and posttest comparison was made by conducting separate calculations for each dimension because the LSI combines measures along two perpendicular continua, Active-Reflective (AE–RO) and Abstract-Concrete (AC–CE). Each continuum was considered separately in the data analysis. An additional category of group interaction was considered in this phase of analysis. In addition to Chat and GSS groups, nearly one third of the sample frame was selected to participate orally to consider the case study. This factor was not included in previous analysis because of recording errors made during the oral group discussion phase of the experiment.

A mixed-model ANOVA using a 3 x 2 design on medium and occasion (pre- and posttest) factors, with repeated measures on occasion factor, was employed to determine the effect of discussion medium upon the Active Experimentation–Reflective Observation (AE–RO) dimension of the LSI. Table 5 presents mean scores for the analysis.

Table 5: Mean LSI Scores (AE–RO) Dimension by Medium

	Pretest LSI Measures	Posttest LSI Measures	Mean (Medium)
Oral	3.72	-2.00	.861
Chat	8.86	6.50	7.68
GSS	6.46	1.08	3.77
Mean (Occasion)	6.35	1.86	

Table 6: Mean LSI Scores (AC–CE) Dimension by Medium

	Pretest LSI Measures	Posttest LSI Measures	Mean (Medium)
Oral	4.72	3.78	4.25
Chat	2.00	5.79	3.89
GSS	8.15	4.69	6.42
Mean (Occasion)	4.96	4.75	

A similar mixed-model ANOVA using a 3 x 2 design on medium and occasion factors, with repeated measures on the occasion factor, was employed to determine the effect of discussion medium upon the Abstract Conceptualization–Concrete Experience (AC–CE) dimension of the LSI. Mean scores of the AC–CE dimension for each level of communication are in Table 6.

Medium (Oral, Chat, or GSS) had no effect on changes in pretest and posttest scores on the AE–RO dimension of the LSI. When considering the medium factor, $F(2, 42) = 2.30$, $p = .111$. When considering the occasion factor, $F(2, 42) = .375$, $p = .690$). Medium (Oral, Chat, or GSS) had no effect on changes in pretest and posttest scores on the AC–CE dimension of the LSI. Differences among group mean scores were not significant for either Medium, $F(2, 42) = .576$, $p = .566$, or Occasion $F(2, 42) = 1.581$, $p = .218$.

Effect of Primer on Learning Style

Half of the subjects were provided an organization chart, suggesting organizational complexity. As before, analysis was conducted on the AE–RO and AC–CE dimensions separately. A mixed-model ANOVA using a 2 x 2 design on primer and occasion factors, with repeated measures on the occasion factor, was employed to determine the effect of the organization chart priming agent upon the Active Experimentation–Reflective Observation (AE–RO) dimension of the LSI. Mean scores of the AC–CE dimension for each level of communication are in Table 7.

In the same manner, a mixed-model ANOVA using a 2 x 2 design on primer and occasion factors, with repeated measures on occasion, was employed to determine the effect of discussion primer upon the Abstract Conceptualization–Concrete Experience (AC–CE) dimension of the LSI. Mean scores of the AC–CE dimension for each level of communication are in the Table 8.

Primer did have an effect on changes in pretest and posttest scores on the AE–RO dimension of the LSI. Changes in scores representing primed versus non-primed

Table 7: Mean LSI Scores (AE–RO) Dimension by Primer

	Pretest LSI measures	Posttest LSI measures	Mean (Primer)
Without organization chart	3.96	-2.25	.8540
With organization chart	8.57	5.86	7.21
Mean (Occasion)	6.27	1.80	

Table 8: Mean LSI Scores (AC–CE) Dimension by Primer

	Pretest LSI measures	Posttest LSI measures	Mean (Primer)
Without organization chart	5.96	4.33	5.15
With organization chart	3.62	5.05	4.33
Mean (Occasion)	4.79	4.69	

groups (between groups) differed significantly, $F(1, 43) = 6.039$, $p = .018$. Within-groups changes from pre-test to posttest, however, were not significant $F(1, 43) = 1.045$, $p = .312$. Primer (presence or no presence of organization chart) had no effect on changes in pretest and posttest scores on the AC–CE dimension of the LSI. Differences between group mean scores were not significant, $F(1, 43) = .167$, $p = .685$. Further, within-groups mean scores did not differ, $F(1, 42) = .865$, $p = .357$.

To summarize the data analysis, Chat groups produced more language than did GSS groups, while GSS groups employed more of the organizational ditransitive verb structure than did Chat groups. While the ratio of verbs to words did not differ among Chat and GSS groups, fewer instances of verbs coupled with increased frequency of ODTV structure suggested increased structural quality of GSS-mediated language. Presence of the priming agent made no impact on the organizational quality of language between groups. Regarding cognitive processing, media made no impact on LSI scores. While the priming agent did not impact AC–CE scores, however, it did impact AE–RO scores, suggesting a change in the reflective quality of thinking while using the organization chart as a priming agent.

Discussion

Results of the analysis provide evidence to suggest that using different modes of computer-mediated communication can facilitate different levels of language complexity and that specific kinds of priming agents can alter learning style in group problem solving contexts. Language complexity and complexity primers, such as the organization chart used in treatment groups, may enhance group members' ability to conceive, employ, and share complex perceptual frameworks. Cognitive processing at the individual level appeared to have been impacted by the independent variables. Variations in language complexity and learning style among the various media and primer treatment groups may serve as evidence for the transfer of perceptual frameworks, suggesting that learning among group members occurred during group interaction.

A number of issues are pertinent to the findings and will be addressed in the following order: impact of medium on language complexity, impact of primer on language complexity, impact of medium on learning style, and impact of primer on learning style.

The Effect of the Medium on Language Complexity

Differences in pretest and posttest measures related to language complexity may indicate that media choice can impact group member language and provide insight as organizational leaders, trainers, and educators make group process-related decisions.

It appears that using different collaborative technologies did provide group members with different experiences as they undertook the case study. The volume of communication among Chat group members far exceeded that of GSS group members. Chat users produced more utterances, words, and verbs to discuss the decision-making case. Although the ratio of verbs to words in Chat groups is proportionate to that of GSS groups, when considering the structure of communication, GSS groups employed the organizational ditransitive

structure (ODTV) much more extensively than did Chat groups.

Inherent differences in GSS and Chat modes of communication may explain the different pretest-posttest measurement outcomes. First, the Chat system provides subjects with a simple text editing (input) area and a single scrollable text box for reviewing recorded text for the entire activity, from start to finish. This interface provided an open and freeform space for contribution, allowing group members to track the discussion and choose whether to contribute to the current topic or branch to other themes at will. Branching occurred frequently, and themes became mixed toward the end of the discussion, much like an oral group activity. Some themes were unrelated to the case problem, such as joking and name-calling. Other contributions were related but not task supportive.

GSS subjects used multiple tools that guided subject interaction during specific periods of time. Further, the ability to transfer content from one tool to another and reuse the content for a different purpose allowed subjects to retain information while refocusing effort to a new purpose. GSS contributions were highly focused on purposes established by each tool. Given the open nature of the Chat system, it is therefore plausible that subject-directed focus facilitates more words, verbs, and utterances, while the GSS-directed focus facilitates more purposeful contributions from members. Salomon (1990) refers to a similar factor as task mindfulness. Thus, it could be that an effect of the GSS system is to enhance the group members' task mindfulness.

Perhaps evidence for enhanced task mindfulness is found in the measurement differences in ODTV; communication complexity may reflect increased mental effort. As a unit of measurement the ODTV may be useful to quantify mental effort objectively.

The Effect of the Primer on Language Complexity

The use of an organization chart as a priming agent appeared to have no effect on the number of words produced, number of verbs, the ratio of verbs to words, the number of utterances, the occurrence of organizational ditransitive structure, or ODTV ratio. Although the hierarchical nature of the firm was implied by use of small but definite structural features, illustrated by departmental boxes and lines of authority common to typical organization charts, features of the chart apparently did not affect the complexity of language structure. Subjects did not comment on the presence of the organization chart, although two separate Chat discussion transcripts include a single utterance reference to receiving different handout packages. Subjects posted no response to these comments; rather, they continued with the ongoing line of discussion. Perhaps the organization chart is an insufficient primer to promote complex description.

While it may be plausible to conclude that the priming agent contained insufficient efficacy to affect discourse, differences in LSI scores between primed and non-primed groups suggest the priming agent did impact learning style. One possible reason that the priming agent appeared to make no impact upon language complexity is that the presence of the CSCW environment directed attention away from the paper-based organization chart. Perhaps only after sufficient experience with the medium would subjects view the case problem material as an equally valid source for solutions as well as a description of the problem. Did group members rely upon information generated during the activity more than upon information contained in the case problem?

Specific implementation strategies may enhance the value of the organization chart as a priming agent. First, group leaders and facilitators can make the organization chart salient by verbally citing it and developing questions to direct participants to reflect upon it. Second, the priming agent can be distributed independently of other information with sufficient time for it to have an effect. Third, the priming agent can be presented online, as a complement to digitally produced text, which may serve to enhance its value within the context of computer-mediated communication.

The Effect of Communication Media on Learning Style

Changes in the AE–RO dimension and the AC–CE dimension on pretests and posttests were insignificant indicating that media had no impact

upon the cognitive processing functions of group members. Several factors may have prohibited identifying a difference within and between scores. First, sample size may have been insufficient to detect real differences in scores. Power for both the AE–RO and AC–CE measures was moderate to low. Doubling or tripling effect size could provide sufficient power to identify meaningful differences in the data. Second, although the LSI has been used for many years as a research and training tool, it may not be flexible enough to measure changes in learning style appropriately. Since the instrument has no historical use as a tool to detect changes in learning style, analysis must be conducted to test such functionality.

Third, and related to the previous comment, the time period of the activity may have been too brief to permit a measurement of change in learning style. While one might expect a difference between the Oral method and either of the mediated methods, a single thirty-five minute experience may not have allowed subjects to transition to alternative learning styles. The impact of Oral, Chat, or GSS methods on learning style must be analyzed over varying time periods, as well as under conditions of intermittent and long-term use.

Fourth, the case activity may not have promoted opportunity for different subjects or groups to fully express their learning style. The Lazy-Days case required subjects to operate within set parameters. The problem was well defined and explained in the case document. The recommended procedure for Chat groups was relatively structured (brainstorming, choosing, refining, and writing) and for GSS groups the agenda followed the same recommended procedure. Further, the output was predetermined—a written plan. Perhaps a more amorphous, less structured problem context would promote varied thinking among and within groups.

The Effect of the Primer on Learning Style

Primer and non-primer group posttest scores did differ from their respective pretest scores on the AE–RO dimension of the LSI, but not on the AC–CE dimension. The nature of the constructs comprising the LSI grid suggests possible reasons that the AE–RO scores shifted as a result of the treatment, while the AC–CE scores did not. The AE–RO scores represent a bipolar construct, with the AE (Active–Experimentation) dimension reflecting a practical orientation to problem solving, emphasizing pragmatic behavior and direct involvement to take action. The RO (Reflective–Observation) dimension differs by its emphasis on understanding and gaining meaningful insight from an experience, discernment of truth from falsehood, and impartial judgment. Posttest scores on this dimension indicate a shift from a moderate AE–RO score to one of a stronger Reflective Observation orientation. Several meanings may be inferred from this finding.

First, the nature of the case problem may produce more of a reflective observation behavioral set. Since significant differences between primed and non-primed groups were found, however, with greater changes in scores among those using the organization chart as a priming agent, it is apparent that the priming agent impacted learning style during the treatment. A two-way ANOVA model may detect an interaction effect analyzing both medium and primer variables. Given the sample frame available in this study, however, such analysis would produce insufficient group size to draw valid conclusions. Increased sample size will allow for such analysis. Various priming agents must be tested for their influence on learning style during group activity contexts.

Second, the organization chart may contain characteristics that predispose subjects to Reflective Observation behavior. Unlike flowcharts, which favor the representation of processes and functions, organization charts tend to represent structures and relationships, which may direct subjects to more idealistic, less practical solutions. Though simplistic, the organization chart illustrated a solid hierarchy of executive management, mid-level management, operational management, and administrative support functions, with no job-level detail. The general nature of the chart, along with simplistically represented reporting relationships, may promote a sense of objectivity and impartiality employed during typical Reflective Observation behaviors, which may bias group member performance in the case study. Perhaps group members can be equipped with their own priming agents, different from those of other group members, to facilitate

higher level group interaction. Further, if these characteristics of the priming agent can encourage a Reflective Observation learning style, then perhaps different types of priming agents can be used to encourage other learning styles. Carefully crafted priming agents may have a developmental effect on group members, which can be used to enhance group performance in contexts with sub-optimal primer availability.

The AC–CE scores represent a bipolar construct, with the AC (Abstract–Conceptualization) dimension reflecting conceptualization, analysis, and theory development and the CE (Concrete–Experience) dimension reflecting intuitive thinking and feeling as well as focusing on immediate circumstances. While there were no significant changes in scores on the AC–CE dimension, movement along the continuum may provide some contribution to the current study. Subjects unaided by a priming agent experienced non-significant score changes toward the Concrete Experience learning style while subjects possessing an organization chart recorded score changes toward the Abstract Conceptualization learning style. Score changes in opposing directions on the AC–CE dimension may suggest that the priming agent may alter learning styles. Considering that differences between pretest and posttest scores on the AE–RO dimension were significant, a richer analysis of changes in learning style can be inferred. Further research using larger group size and a broader range of problem contexts is necessary to determine more accurately the nature of shifts in learning style when using priming agents in distributed computing environments.

Overall, the fact that AE–RO scores with treatment differed and AC–CE scores did not may suggest that groups equipped with organization charts became less personally involved in the facts of the case, undertaking an advisory role with less personal concern and responsibility for the situation and its outcome. An orientation toward the Reflective Observation learning style focuses on understanding the meaning of ideas and situations by carefully observing and impartially describing them. It emphasizes understanding as opposed to practical application, a concern with what is true or how things happen as opposed to what will work, and an emphasis on reflection as opposed to action (Kolb, 1984). A combination of factors may have produced this effect including media effects, priming agent effects, case problem bias, priming agent bias, or undiscovered intervening factors.

Recommended Future Research

Findings from this study suggest that researchers can make important gains by extending this research in several areas. The impact of the priming agent on learning in this study suggests that there are perhaps many environmental cues that stimulate thinking for groups involved in a decision making process. More specifically, a computer supported collaborative environment may restrict, enhance, or in some way mediate these cues to impact group performance. New or alternative measurement techniques to assess changes in cognitive processing can improve theory building in CSCW. A typology of computer-mediated support systems based upon their respective effects upon learning can assist researchers in better understanding existing and emerging technologies, as well as practitioners as they use emerging technology in the workplace. Finally, researchers must discover new and objective units of behavioral observation that exist in computer-mediated group communication. Observing mental model transfer can never be realized without some unit of observation.

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