Effect of GSS and Facilitation on Knowledge Restructuring

Ron Chi-Wai Kwok
Department of Information Systems
City University of Hong Kong
isron@is.cityu.edu.hk

Jian Ma
Department of Information Systems
City University of Hong Kong
isjian@is.cityu.edu.hk

Doug Vogel
Department of Information Systems
City University of Hong Kong
isdoug@is.cityu.edu.hk

Abstract

In this paper, a 2 X 2 factorial design was used to assess the main and interaction effects of GSS and facilitation on knowledge restructuring under experimental conditions. To measure knowledge restructuring, the concept mapping technique and similarity coefficient were used to evaluate the level of restructuring of individual structural knowledge (complexity and integration) and the commonality of individual knowledge among the group. Results of the experiment indicated that both GSS and facilitation were effective cognitive tools which could be used to enhance knowledge restructuring. Supplemental analysis revealed that the presence of either GSS or content facilitation improved quality of learners' feedback which was an important factor needed to heighten restructuring of learners' mental models. However the interaction effects of GSS and facilitation on knowledge restructuring were found to be non-additive.

1. Introduction

The use of GSS over the last decade has shown to enhance the communication of teams working under high cognitive loads (Briggs et al., 1998). Many studies have reported higher quality outcomes and satisfaction, and reduced social pressure and attention blocking for groups using GSS (e.g., Dennis and Gallupe, 1993). Based on the success of using GSS to support collaborative work, recent research focuses on the application of GSS in academic organizations as GSS is recognized as an effective tool that can enhance knowledge acquisition (e.g., Alavi, 1994; Kwok and Khalifa, 1998). Although the prior GSS research findings regarding learning are encouraging and suggest that GSS may be used to improve learning under certain situations, there are still many questions needed to be answered. Particularly, facilitation effect on GSS-supported learning has received less attention.

Facilitation has been applied in teaching and training, and regarded as a critical dimension in self-directed learning, group learning and organizational learning, in both synchronous and distributed environment. In today's schools, a teacher's role shifts from instructor to facilitator emphasizing more on andragogy than pedagogy. A facilitator's role is to aid learning, engage students through interactive questions or exercises, and manage the process and structure of the learning interaction (Aakhus et al., 1997).

As a growing body of researchers applying technologies in schools (Slavin, 1995; Alavi, 1994; Kwok and Khalifa, 1998), the importance of facilitation may increase. Despite the great impact of facilitation in GSS-supported collaborative learning, very few empirical studies investigate the effectiveness of such intervention. This paper investigates the effects of GSS and facilitation on knowledge acquisition under experimental conditions.

Section 2 of this paper presents the theoretical background of the study and its hypotheses. Section 3 describes the measurement of knowledge structure. Section 4 illustrates the design of the empirical study. Section 5 presents and discusses the results of the study, explains its limitations and implications, and suggests future research directions.

2. Background and Hypothesis

Knowledge acquisition can be composed of two components: personal and social (Entwistle and Entwistle, 1992). According to cognitive theory of learning, knowledge is personal in that it depends on the previous knowledge of the learner to interpret new information. Previous knowledge is thus necessary and important to the achievement of knowledge acquisition, but it is the way in which it is organized rather than merely the amount that is important (Burns et al., 1990).

Knowledge acquisition also has a social component. Pask (1976), in his conversation theory of learning, suggests that knowledge acquisition can be built through conversation with others about the subject. Rather than
transferred by experts or teachers, individual knowledge is acquired from the existing tacit knowledge held by individuals participating as their contribution of the knowledge creation of the entire group (Leidner and Jarvenpaa, 1995). According to the collaborative learning model, individual knowledge emerges through interaction of individuals with other individuals. Whereas the knowledge of the individuals is shared, a new shared knowledge emerges among the participants (Slavin, 1995). It enables higher-order cognition and conceptual learning.

Based on the cognitive theory of learning, knowledge acquisition emerges from assimilation - the interaction of a stimulus or problem and the mind of the learner, and results in accommodation (knowledge restructuring) - a change to the learner's mental model (Vandenbosch and Higgins, 1996). More specifically, when a problem can be effectively recognized, understood, and dealt with the existing mental model (prior knowledge) involving the encoding of new information, assimilation occurs. When a mental model must be changed in order to deal effectively with the problem, accommodation occurs.

With the stimulation of a problem, the individual learns personally as well as socially with his/her own effort during a classroom discussion, resulting in the accommodation of his/her own mental model with the purpose to assimilate the problem. Based on Nonaka's theory of organizational knowledge creation (Nonaka, 1994), learners can help each other to learn by sharing their knowledge and giving feedback to each other.

By contributing to the classroom discussion, the individuals can externalize their internal tacit knowledge into transmittable and communicable explicit knowledge which is then combined, distributed and shared by other learners of the group in the form of initiated ideas, feedback and questions etc. Afterwards, the individuals can internalize the combined knowledge by retrieving, interpreting and integrating it with their existing mental model resulting the accommodation of a new set of mental model. In addition, the individuals can also learn from each other by socialization through observation, imitation and practice.

Giving (externalizing) and receiving (internalizing) feedback in a collaborative environment enhance assimilation and accommodation. Bargh and Schul (1980) suggested that preparing to give feedback in response to a question or comment could produce a more highly organized cognitive (knowledge) structure than only trying to learn from others’ feedback. They also suggested that group feedback and sharing of resources help group members reshape their ideas and learn new information that they might not discover on their own. The notion of the individual as an active processor of information, rather than a passive receiver, is at the heart of Wittrock’s (1974) model of learning as a generative process. In Wittrock’s model, the learner generates associations between new information and concepts already learned. When learners in groups help each other, they can compare and assimilate the new information to previously acquired information, and accommodate existing concepts as necessary.

In this paper, we postulate that GSS and facilitation enhance the personal and social components of knowledge acquisition. Both of the interventions encourage learners to give and receive feedback in a collaborative learning environment. Nunamaker et al. (1991) suggested that GSS enhance group processes by increasing group process gains and/or group processes. The effects of GSS on group process gains/losses contribute to the three attributes of effective learning (i.e. active engagement, cooperation, and problem-based learning) and facilitate knowledge acquisition in the task domain (Alavi, 1994). Kwok and Khalifa (1998) suggested GSS encourages the learners to provide feedback that is useful for generating and reinforcing understanding of the learning task by through information sharing, learners’ participation and objective evaluation for catching errors, and by reducing meeting time fragmentation and fear of reprisal. GSS also encourages positive interpersonal communication and relationships. In addition, GSS helps the learners better understand and analyze task-related information by structuring the task, using techniques, rules, and models. It enables learners to perform a deeper analysis of the problem, resulting in a better task understanding. GSS also helps reduce incomplete use of shared feedback by providing information and computation infrastructure to the group (Nunamaker et al., 1991).

Facilitation is another important intervention which could affect knowledge restructuring. The essential function of the facilitation is to create and protect the group meeting environment on which group process can take place easily (Phillips and Phillips, 1993). The main task of a facilitator is to improve a group’s communication and information flow, and to make the outcome easier to achieve (Griffith et al., 1998). A facilitator is also a process guide and someone who makes a process easier or more convenient. Based on the content facilitation approach proposed by George et al. (1992), the facilitator can also provide the group with flexible content feedback in response to the group need. He or she can also take an active role in the meeting to provide expert advice, direction and counseling to the group.

By managing the sequencing, connectedness of the group activities, and breaking the task into smaller and more manageable pieces, the facilitator can ease the group’s work and help the learners better focus and analyze task-related information. Also, the facilitator enables learners to perform a deeper analysis of the problem, resulting in a better task understanding without inhibiting the creative exploration of issues. Facilitating learner interaction, in this way, enables learners to learn
and develop by self-discovery and personal insight. Therefore, learners are encouraged to contribute ideas actively in the meeting. By managing the socioemotional issue of meeting, the facilitator keeps learners in a resourceful and positive emotional state (Kelly and Bostrom, 1998). It encourages effective task and relationship behaviors among learners, and deal with disruptive influences in the meeting (Bostrom et al., 1993).

All of the above effects of facilitation and GSS contribute positively to the personal and social component of knowledge acquisition. Therefore, our empirical study aims at verifying the following hypotheses.

H1: Subjects in a GSS supported collaborative learning environment will attain a higher level of knowledge restructuring than subjects in a collaborative learning environment that is not supported by GSS.

H2: Subjects in a facilitated collaborative learning environment will attain a higher level of knowledge restructuring than subjects in a collaborative learning environment that is not supported by facilitation.

Based on the Adaptive Structuration Theory, Anson et al (1995) pointed out that the structures provided by a facilitator and GSS are expected to complement one another, resulting in additive supplemental or enhancement effects on appropriation processes, and hence group outcomes. A GSS makes various constructive group process structures available to support and guide their faithful appropriation through automated features, interfaces, and processing routines. A facilitator sets effective agendas and brings his or her own knowledge to the GSS-supported meeting. He or she extracts, chooses, and adjusts group process structures grounded on his or her own expertise. By giving guidelines to encourage faithfulness, as well as encouraging positive attitudes and consensus over the GSS-supported structures’ use, the facilitator can help the group successfully appropriate these structures (Anson et al., 1995). Based on the findings of GSS field and experimental studies (e.g., Dennis and Gallupe, 1993), a constructive interaction could occur when facilitation and GSS are used together, adding their influence to produce better group processes and outcomes. This forms our third hypothesis regarding the additive effects of GSS and facilitation on knowledge restructuring.

H3: The combined effects of GSS and facilitation on knowledge restructuring are additive.

3. Measurement of Knowledge Structure

In this study, the principle of concept map (Novok and Gowin, 1984) and similarity coefficient (Johnson and Wichern, 1992) were employed to measure student’s knowledge structure in terms of knowledge complexity and integration, as well as the knowledge commonality.

A concept map is a graphical representation of meaningful relationships between concepts. It is a semantic network describing a knowledge structure: ideas and their interrelationships. With concept maps, learners can develop a schematic representation of their mental model regarding a particular knowledge domain through the externalization and visualization of concepts and meaningful relationships between them (Novak and Gowin, 1984). A concept map consists of a graph where the nodes represent the concepts at different levels of abstraction and the direct-links and cross-links represent meaningful relationships between these concepts. Direct-links relate concepts that belong to the same hierarchy. They are useful for defining general concepts in terms of more specific concepts. Cross-links relate concepts from different hierarchies. They are useful for representing meaningful relationships between different concepts (Khalifa, 1998). Cross-links are usually more difficult to learn than the direct-links. Concept mapping technique can be used to illustrate the student’s knowledge structure (individual understanding) which can be characterised by its complexity and its level of integration. The total number of valid direct-links in the associated concept map was used to measure the complexity of a knowledge structure. On the other hand, the total number of valid cross-links was used to measure the integration of the knowledge structure.

To compare the commonality of the links of a pair of two concept maps, the presence or absence of each link in the two concept maps was described mathematically by a binary number. Value 1 was given if the link was present in a particular concept map and value 0 if the link was absent. The total frequencies of matches (1-1 match) and mis-matches (1-0 or 0-1 match) of links of the pair of concept maps were obtained. Using the Jaccard measure (Johnson and Wichern, 1992), similarity coefficient (commonality) of the pair of concept maps was then determined. Jaccard measure gave equal weight to matches (1-1) and mismatches (1-0 & 0-1). The value of the commonality lied between 1 and 0 (1 = entirely identical; 0 = entirely different).

In a group of 4 students, it is necessary to compare each concept map with the other three of the group. Therefore, three scores of commonality were obtained for each concept map. To measure the level of knowledge commonality of a student, we averaged the three scores of commonality. A high average level of knowledge commonality of a student implied that there was a high
level of knowledge commonality between the student and the other members of the group.

4. The Empirical Study

To test the hypotheses presented earlier, an empirical study was conducted under experimental conditions. Each subject of the experiment was required to complete the following collaborative task.

4.1 The Task

The collaborative task involved the development of an evaluation scheme for the term project of an undergraduate course. It was a task that the students had to learn as part of a collaborative assessment method (Kwok and Ma, 1998) applied in teaching the course. To provide students necessary information to complete the task, the instructor explained the definition of a list of pre-set assessment criteria, the course objectives, the available learning resources, and the assessment guidelines and policy of the university before the commencement of the task.

In the main study, the collaborative task was carried out in the following three steps and lasted for about half an hour. Based on the data collected in the pilot study, the time limit for the completion of each step was assigned.

1. The students were asked to brainstorm the definition and description of all related aspects of the pre-set and newly created criteria with respect to the course objectives, the learning resources and constraints. (12 minutes)
2. The students were then asked to discuss why the criteria are appropriate to be used to assess the student project. (16 minutes)
3. Following a two-round voting procedure, the students were required to select five criteria and assign weights reflecting the relative importance of the selected criteria. (5 minutes)

4.2. Experimental Design

A 2 X 2 factorial design was used to assess the main and interaction effects of GSS and facilitation on knowledge restructuring. In all, 128 undergraduate students enrolled in a Management Information Systems course participated (32 in the pilot study and 96 in the main study). They were randomly assigned to the above 4 four-member groups of different treatments:

- Group 1. Baseline: Manual Face-to-face (non-GSS) without facilitation
- Group 2. Content Facilitation only: Manual Face-to-face (non-GSS) with facilitation
- Group 3. GSS only: Face-to-face with GSS support, and without facilitation
- Group 4. Combined: Face-to-face with GSS support, and with facilitation

GSS Treatments

The GroupSystems software (Nunamaker et al., 1991) was used for the GSS-only and combined treatments. Students were seated around a table in a small GSS laboratory. In front of each student was a computer workstation, networked to run the software. Features of the software such as simultaneous & parallel processing and anonymity permitted students to work interdependently as well as in a group. The software provided the following tools: 1) brainstorming, and 2) voting. The software also supported anonymity in order to enable the students to voice their opinion freely without fearing a direct confrontation with the instructor and the other students.

Facilitation Treatments

The instructor employed the content facilitation approach. It was to provide the group with flexible content feedback in response to the group needs. The instructor took an active role in the meeting to provide expert advice, direction, and counseling to the group. Flexibly content-facilitated groups were expected to have high levels of meeting outcomes. However, to prevent the inappropriate power and information processing effect of facilitator influence on the group, the instructor was reminded to make only indirect contributions to the discussion through neutral enhancement of the processes of communication and information processing by the group. In addition, for the combined treatments, every contribution made by the instructor was identifiable, which was displayed on the monitor followed by the word “Tutor”.

Baseline Treatments

Throughout the whole collaborative task, the baseline groups used the traditional face-to-face method to communicate among students of the group. The main role of the instructor was to monitor the process of the meeting, and to record the used time for each step of the experimental procedure. At steps 1 and 2, the students discussed the assessment criteria with each other through verbal communication without interacting with the instructor. At step 3, the students selected their own sets
of assessment criteria using the manual two-round voting procedure.

To prevent biased subjects across the four experimental groups, the homogeneity of students was tested and found that there was no significant difference between subjects in four treatments regarding to their age, sex and prior experience with the GSS tool and the concept mapping technique used in the experiment. Based on the feedback received from the pilot study, the training sessions on usage of GSS and concept mapping technique were organized in a more intensive mode than that of the pilot study.

4.3. Experimental Procedure

To test the research hypotheses, the students were randomly assigned to four groups as mentioned before. Each group was divided into 6 sections of 4 students each. Each section participated in a separate session. Each session lasted about 1.5 hours and involved the performance of the collaborative task described earlier.

For evaluating students’ initial knowledge structure concerning the evaluation scheme, they were required to draw a concept map regarding to the eight pre-set assessment criteria according to three dimensions: 1) project outcome or project process; 2) knowledge, skill or attitude; 3) learning objective. The students could add new assessment criteria to the concept map. This step lasted for 10 minutes. After completing the collaborative task, the student were also required to draw another concept map regarding to the eight pre-set and newly created assessment criteria according to three sets of dimensions. This step also lasted for 10 minutes.

To determine the restructuring of a student’s knowledge complexity and integration, we firstly located the new valid links found in his/her concept map drawn after the experiment by comparing it with the one drawn before the experiment. Then, the new links were categorized into either direct or cross-links. Finally, the total number of new direct-links found were used as a measure of the change of a student’s knowledge complexity, and the total number of new cross-links located as a measure of the change of knowledge integration. To determine the change of the student knowledge commonality, we subtracted his/her pre-experimental commonality score from his/her post-experimental commonality score.

To ensure the reliability of the measurement, two coders were instructed to rate independently the same set of students’ concept maps. Their levels of agreement exceeded 90%, indicating adequate inter-rater reliability. Remaining differences were resolved through a discussion between the two coders.

5. Results and Discussion

The collected data was analyzed using ANOVA and LSD test. The ANOVA and LSD results were summarized and shown from Table 1 to 3.

### Table 1. Means and ANOVA Results for Knowledge Complexity

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<th>Mean Score</th>
<th>Summary of ANOVA and LSD Tests</th>
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<td></td>
<td>Non-GSS</td>
<td>GSS</td>
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<tr>
<td>Non-Content Facilitation G1</td>
<td>5.17</td>
<td>4.92 (G3)</td>
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<tr>
<td>Content Facilitation G2</td>
<td>5.29</td>
<td>4.42 (G4)</td>
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### Table 2. Means and ANOVA Results for Knowledge Integration

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<th>Mean Score</th>
<th>Summary of ANOVA and LSD Tests</th>
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<tr>
<td></td>
<td>Non-GSS</td>
<td>GSS</td>
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<tr>
<td>Non-Content Facilitation G1</td>
<td>2.25</td>
<td>3.96 (G3)</td>
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<tr>
<td>Content Facilitation G2</td>
<td>3.96</td>
<td>3.00 (G4)</td>
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The ANOVA results (see Table 1 to 3) indicated that the main effects of GSS on knowledge complexity, integration and commonality were not significant. However, the LSD tests showed that the students in group 3 (GSS only) constructed knowledge structure with significantly higher level of integration and commonality than that in group 1 (baseline). It suggested that group interaction with GSS support helped students to construct a more integrated knowledge together with a higher degree of commonality among group members than did students without GSS support.

The analysis of the supplemental observation and questionnaire data indicated that the main contribution of GSS to knowledge construction only comes from its positive effects on the social component of knowledge acquisition. The GSS improvement of group process gains and decrease of group process losses encourages the learners to provide each other with better feedback that is useful for validating or enhancing their mental models. By reducing domination and evaluation apprehension and by increasing the feedback level and improving the objectivity of evaluation, GSS contributes to a more cooperative environment. The feedback received through conversation helps the individual to restructure and improve his/her knowledge.

Concerning the main effects of content facilitation on knowledge restructuring, the ANOVA results (see table 1 to 3) indicated that the presence of content facilitation did not improve knowledge complexity and integration, but enhance knowledge commonality. The concept map data supported that the content facilitation helped the students construct a knowledge structure with a higher degree of commonality among group members than would occur without content facilitation. Moreover, the LSD tests showed that the students in group 2 (content facilitation only) constructed knowledge structure with significantly higher level of integration and commonality than that in group 1 (baseline). It suggested that group interaction with content facilitation support also helped students to construct a more integrated knowledge than did students without content facilitation support.

In the content-facilitated learning environment, the facilitator took an active role in the meeting to provide neutral feedback, direction and guidance to the group. However, according to the Facilitator Influence Model (Griffith et al., 1998), the strength of a facilitator’s influence will be weighty if the facilitator has expert power or status. Learners may perceive the content facilitator as an expert facilitator. In this way, the content facilitator’s feedback might influence the learners to enhance and accommodate their mental models towards the facilitator’s direction. It might lead to the construction of knowledge structures with a high degree of commonality among group members. This could be a reason why the presence of content facilitation could improve knowledge commonality.

Although the ANOVA results (see Table 1 to 3) indicated that the interaction effects of GSS and content facilitation on the knowledge complexity were not significant, the interaction effects of GSS and content facilitation on knowledge integration and commonality were found significant but non-additive. The combined cell means (with GSS and with content facilitation) on knowledge integration and commonality were not found to be higher than the other cell means.

The positive effect of content facilitation on knowledge commonality was found to be neutralized by the presence of GSS (see Figure 1). The LSD tests (see Table 3) showed that the students in group 2 (with content facilitation and without GSS support) acquired knowledge with significantly higher level of commonality than that in group 4 (with content facilitation and with GSS support). A large number of alternatives, ideas and feedback could be generated in a GSS-supported environment while the normative influence of the majority or a powerful minority (i.e., facilitator’s influence) is eliminated (Dennis et al., 1988). The “expert” status effect of content facilitation was therefore canceled out in the GSS-supported environment.

<table>
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<th>Table 3. Means and ANOVA Results for Knowledge Commonality</th>
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<td><strong>Mean Score</strong></td>
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<td>Non-Content Facilitation</td>
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<td>Content Facilitation</td>
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Moreover, the results show that the positive effect of GSS on knowledge integration was substituted by the presence of content facilitation. Table 2 indicates that the students in group 3 (with GSS and without content facilitation) acquired knowledge with a higher level of integration than that in group 4 (with GSS and with content facilitation). The status influence of the facilitator on the group may be still too strong, even though it was neutralized by the presence of GSS as mentioned above, the students were stimulated to rely on the content facilitator to complete the learning task. It stopped students from becoming active in the process of knowledge acquisition. The supplemental data analysis showed that content facilitation improved quality of student feedback which is an important element for knowledge restructuring. Therefore, we suggest that we could make the facilitator’s feedback anonymous so as to moderate the status influence of the facilitator on the group as well as to enhance the quality of student feedback. The setting of With GSS and with anonymous content facilitation might be a better learning environment to enhance knowledge restructuring. The potential of such an environment remains to be carefully examined.

This study is not without limitations. There are a number of factors related to the setting of the experiment. The first limitation relates to the nature of the rewarding scheme of the task. The task for the experiment was highly motivating for the students, as its outcome affected whether the students could receive additional cash rewards. The students were externally motivated by the cash rewards. Such a highly motivating task promotes active participation which is one of the main attributes of effective learning. Would the results of the experiment be similar had the task rewarding scheme not been as motivating?

The second limitation relates to the constraint of the content facilitation. The results of a field study indicated that a student size of 20 seemed manageable and the most pleasing to the students for electronic discussions (Leidner and Fuller, 1996). However, if we asked a content facilitator to take care of a group of 20 electronically, it would be very difficult for him/her to give instant feedback to the group.

Despite the limitations, this research has been helpful in laying the groundwork for a better understanding of the application of GSS and facilitation in the collaborative learning environment. Although the former analysis found support for some, though not all, of the hypotheses we have outlined, it is clear that more research is needed to advance our understanding of GSS and facilitation in the classroom and help answer fundamental questions such as: Does GSS and facilitation help knowledge acquisition? If so, which types of learning tasks are most appropriate for GSS support and facilitation and how do GSS and facilitation help? What is the effect of different levels of GSS and facilitation on different types of learners? Which group sizes are most appropriate? What are the factors of success for implementation (e.g., training for facilitators)?

GSS has expanded from a synchronous (same time/same place) environment to a further three modes of environments (same time/different place, different time/same place and different time/different place) in which learning can take place. The time has come to move our thinking about GSS and facilitation support in these three modes of learning environments.

References


