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Knowledge Acquisition Through Computer-Mediated Discussions: Potential of Semantic Network Representations and Effect of Conceptual Facilitation Restrictiveness

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KNOWLEDGE ACQUISITION THROUGH COMPUTER-MEDIATED DISCUSSIONS: POTENTIAL OF SEMANTIC NETWORK REPRESENTATIONS AND EFFECT OF CONCEPTUAL FACILITATION RESTRICTIVENESS

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Abstract

With the increasing importance of computer-mediated discussions for supporting knowledge management activities, the role of discussion representation in knowledge acquisition can no longer be neglected. In this research, we investigate the potential of semantic network discussion representations. Specifically, we compare linear discussion representations to semantic network discussion representations at different levels of conceptual facilitation restrictiveness in terms of their effects on knowledge acquisition. Based on a field experiment, we demonstrate that semantic network discussion representations enable the acquisition of more complex and better integrated knowledge structures than linear discussion representations. Our empirical results also show that conceptual facilitation restrictiveness hinders knowledge acquisition. The theoretical and empirical implications of these findings are discussed.

Keywords: Knowledge acquisition, computer-mediated discussion representation, semantic networks, facilitation restrictiveness

Introduction

We have witnessed a proliferation of computer-mediated discussions in recent years. In some contexts, they are used to support the social interactions among the members of online communities, such as communities of interest. In other contexts, their primary role is to support knowledge acquisition and exchange. In communities of practice, for example, computer-mediated discussions support the externalization, communication, and internalization processes of knowledge sharing among the members (Nonaka 1998; Wenger 1998). Computer-mediated discussions are also used to support collaborative learning. In academic institutions, for example, students conduct computer-mediated discussions as part of their learning activities. Several companies are also using computer-mediated discussions for the online training of their employees. Computer-mediated discussions are indeed believed to be an important enabler of knowledge acquisition by both researchers (Leidner and Jarvenpaa 1995; Vogel et al. 2001) and practitioners (Kaplan 2002). According to some statistics, over 2,000 business professionals consider computer-mediated discussions as one of the top three enablers of knowledge acquisition (Kaplan 2002).

An extensive part of the literature on computer-mediated discussions focused on group support systems (GSS) and their effects (i.e., enhancing group process gains and alleviating group process losses). Prior research reported conflicting results regarding GSS effects, suggesting the need for contingency theories. Dennis and Wixom (2002) performed a meta-analysis to study several intervening variables, namely, task, group type, group size, and facilitation. The mediating and moderating variables advocated by the contingency theories were mainly related to group dynamics and task nature. Very little has been done to examine the role of discussion representation, which can be another important factor affecting the effectiveness of computer-mediated discussions. Discussion representation in traditional computer-mediated discussions is dominated by the linear format with a hierarchical representation of the discussion using threads of ideas and comments. Linear representation of information, however, may not be the best fit for the associative nature of the human mind (Khalifa and Kwok 1999). It is, therefore, important to consider alternative representations, for example, semantic networks. The effectiveness of semantic network discussion representation, however, remains to be verified.

Furthermore, the application of the semantic network representation to computer-mediated discussions introduces a new challenge of facilitation restrictiveness. With linear discussion representation, the concept of facilitation restrictiveness is limited to content and process facilitation. With semantic network discussion representation, restrictiveness is extended to conceptual facilitation (i.e., validating the network organization of the discussion). While some studies on content and process facilitation have established the negative effects of restrictiveness on knowledge acquisition (e.g., Khalifa et al. 2002), it is still not clear how conceptual facilitation affects knowledge acquisition in computer-mediated discussions.

Our key research objective is, therefore, to study the effects of discussion representation and conceptual facilitation restrictiveness on knowledge acquisition in computer-mediated discussions. Specifically, we compare linear discussion representations to semantic networks discussion representations at different levels of conceptual facilitation restrictiveness in terms of their effects on knowledge acquisition.

This study provides significant contributions to both research and practice. On the theoretical side, we establish and empirically demonstrate the relationship between discussion representation and knowledge acquisition. In addition, we define a new dimension of facilitation (i.e., conceptual facilitation) and explain its effect on knowledge acquisition. On the practical side, our study provides evidence of the potential of semantic networks for discussion representation, highlighting its advantages over linear discussion representation to designers of computer-mediated discussions. Our results also provide guidelines for selecting appropriate levels of conceptual facilitation for contexts where knowledge acquisition is an important goal of the discussion.

The layout of this paper is organized as follows. We first present a literature review on discussion representation and facilitation restrictiveness. Then we explain our conceptual framework and justify its hypotheses. Next, we describe the research methodology followed by a discussion of the empirical findings. In the conclusion, we summarize our results and suggest implications to research and practice.

Semantic Networks Versus Linear Discussions

Wang and Rada (1998) define a semantic network as "a directed graph in which concepts are represented as nodes and relations between concepts are represented as links." It is a map of the cognitive terrain that surrounds and gives meaning to a concept and through which each concept is ultimately understood (Sowa 1993). A concept is a unit of information that can be represented by a word or phrase and the meaning of which is embodied in its relations to other concepts. Relations, on the other hand, are a special category of concepts that depict the linkages between and among concepts. An instance, sometimes termed a proposition, is a unit composed of two concepts and their relationship. As each concept can be linked to many other concepts, semantic networks can be complex and multidimensional (Fisher 1992). Several empirical studies (e.g., Last et al. 2001; Shum and Selvin 2000; Wang and Rada 1995) demonstrated the superiority of semantic networks over linear text in a variety of contexts and on a number of dimensions, namely, *visualization*, *conceptualization*, and *contextualization*.

Semantic networks support visualization of the discussion with their network-based navigational structure, which allows the user to recognize the many-to-many relationships between the various contributions of the participants (Wang and Rada 1995). The visualization capability makes the navigation in semantic networks more flexible, efficient, and active, as compared to the rigid and passive navigation in linear text. The importance of visualization becomes more salient in large discussion forums. The network-based structure enables users to detect and avoid the redundancy usually encountered in linear discussion representations (i.e., submitting the same idea to different threads of the discussion). The linear discussion representation is more likely to create confusion when the discussion is evolving rapidly with a large number of contributions, such as ideas and comments (Trigg 1996; Wang and Rada 1998).

In addition to improving visualization, a semantic network discussion representation can also enhance the conceptualization of the discussion (Al-Qaimari et al. 1994; Gaines and Shaw 1992). Conceptualization occurs when an individual attaches meaning to the new information by relating it to his own mental model (Wittrock 1974). Semantic networks offer a framework for the interpretation of the information by connecting information meaningfully as a network structure that is more compatible with human information processing than a sequential representation (Last et al. 2001; McDonald and Stevenson 1999; Novak and Gowin 1984).

The third dimension, contextualization, is similar to conceptualization in that it also provides a framework for the interpretation of the information. This framework, however, is based on the context, on the environment, domain, or setting of the contribution (Mittal and Paris 1995). Discussion forums that employ a semantic network discussion representation may provide a richer domain context through the association of the contribution with a concept or a proposition. This association represents contextual information on the contribution's conceptualization that is intended by the contributor.

Semantic networks are not, however, without limitations. The network structure is difficult to change as the discussion emerges. A fundamental change to a node (e.g., redefining a concept), for example, may require revisiting of its links (propositions relating the focal concept to others). Furthermore, with a large number of contributions, the network could become too complex, undermining the visualization advantage (Nosek and McNeese 1997). Conceptualization may also be hindered in large semantic networks, where the hierarchies of relationships are more difficult to deduce (Lo and Nashid 1993). There is also a risk that the conceptualization of the discussion, when being too restrictive, would limit the generation of more novel ideas (Khalifa and Kwok 1999; Niederhauser et al. 2000).

Facilitation Restrictiveness

Extensively studied in GSS research, facilitation is classified into two major types: process facilitation and content facilitation (Dennis and Wixom 2002; Miranda and Bostrom 1999). Process facilitation refers to the procedural intervention by a facilitator to the structuring of group processes, often taking the form of guiding the use of GSS tools or/and ensuring adherence to the meeting agenda. Content facilitation, on the other hand, involves direct intervention on the discussion content to improve the quality of contributions (Zorn and Rosenfeld 1989). With traditional computer-mediated discussion forums, content facilitation is limited to providing guidance and feedback on the content of the discussion. With semantic networks, facilitation is extended to the conceptualization of the content (i.e., structure of discussions), giving rise to a new dimension of facilitation (i.e., conceptual facilitation). As the computer-mediated discussion evolves, the participants suggest new concepts, links, and cross-links for organizing the contributions. Conceptual facilitation, therefore, refers to the validation of the organization of the discussion (i.e., the network structure). This dimension of facilitation is irrelevant to linear discussion representations, where new contributions are simply organized as new threads without consideration for nonhierarchical linkages to prior contributions. The literature reports mixed results on the desirable level of content facilitation restrictiveness, varying across contexts (Khalifa et al. 2002; Wheeler and Valacich 1996). As different contexts may require different levels of content facilitation (e.g., high restrictiveness for decision making and low restrictiveness for learning), they may also require different levels of conceptual restrictiveness. It is, therefore, important to provide computer-mediated discussions with the capability of defining the desirable level of conceptual restrictiveness.

Potential disagreements regarding the discussions can be resolved at different levels of restrictiveness reflecting the degree of interventionism of the facilitator. The least restrictive conceptual facilitation allows complete freedom for the participants to add concepts and propositions. The newly created concepts and propositions are automatically accepted unless removed by the authors themselves within the validation time frame. The moderate level of restrictiveness allows the participants to collectively decide through a voting process. The cut-off voting score is determined at the creation of the discussion forum. The organization of the discussion network structure is decided collectively by all participants. The resulting discussion should be more representative of the collective mental model of the participants. At the highest level of conceptual facilitation restrictiveness, the acceptance of newly created concepts and propositions is under the full control of the discussion facilitator. To keep a concept or a proposition, the participants must convince the facilitator of the proposed conceptualization, who may otherwise reject the contribution. The organization of discussion is, therefore, entirely decided by the facilitator.

Conceptual Framework and Hypotheses Development

Our conceptual framework (Figure 1) is based on several theories, namely, the schema theory (Rumelhart et al. 1972), the information organization framework (Mayer 1979), and the constructivism epistemology (Vygotsky 1978). Applying this framework, we investigate the effects of discussion representation and conceptual facilitation restrictiveness on knowledge acquisition. Specifically, we compare the effect of linear discussion representation to that of semantic network discussion representation on knowledge acquisition, accounting for different levels of conceptual facilitation restrictiveness. In the following sections, we present the conceptualization of knowledge acquisition, followed by detailed justifications for the hypothesized effects.

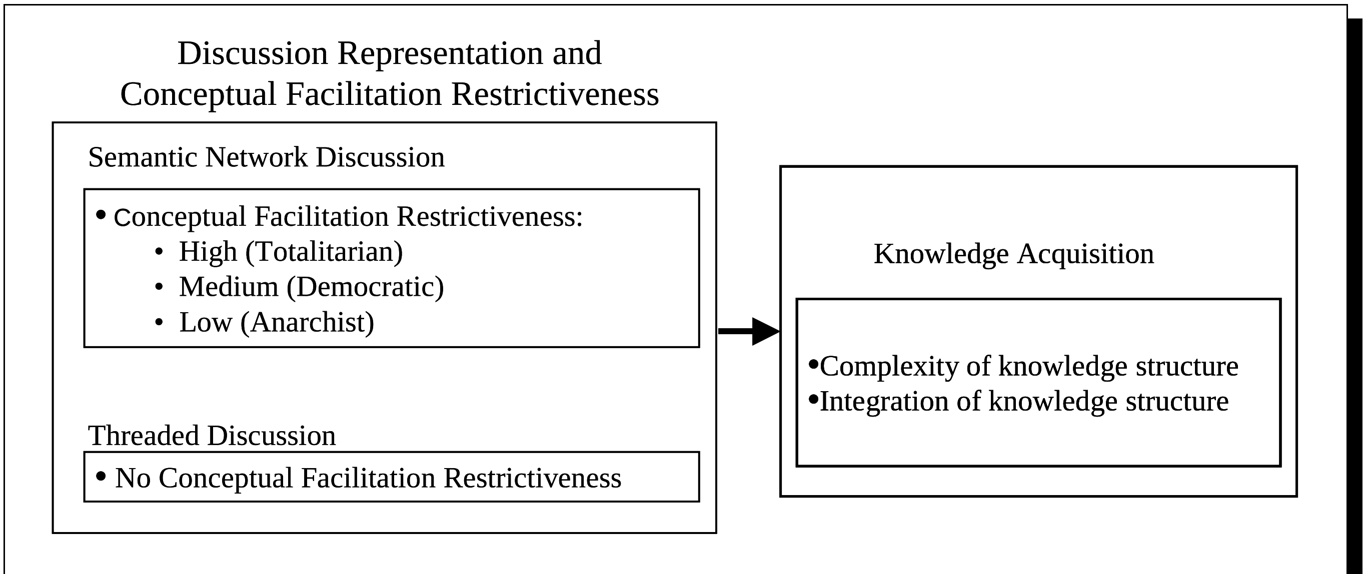

Figure 1. The Conceptual Framework

Knowledge Acquisition

Previous research identified three levels of knowledge, namely, declarative, structural and procedural knowledge (Diekhoff 1983; Ryle 1949). Declarative knowledge, being the lowest level, refers to the awareness of some object, event, or idea. Procedural knowledge describes the use or application of the declarative knowledge (Ryle 1949). The translation of declarative knowledge into procedural knowledge involves structural knowledge, which represents the individual's awareness of his/her own knowledge structure or mental model. Structural knowledge contributes to the construction of relationships that integrate the declarative knowledge into meaningful mental models. It is the cognitive structure or the pattern of relationships among concepts in memory (Preece 1976). It is often conceptualized as internal connectedness, integrative understanding, and conceptual knowledge (Jonassen et al. 1993). In this study, we focus on the acquisition of structural knowledge and adopt its conceptualization by previous researchers as complexity and integration of knowledge structure. The importance of structural knowledge as a key dimension of cognitive skills motivates such focus (Markham et al. 1994; Robertson 1990).

Effect of Discussion Representation on Knowledge Acquisition

Several information representation theories advocate the superiority of the semantic network discussion representation over the linear discussion representation in terms of effects on knowledge acquisition. Such superiority is attributed to the network-based structure and the explicit illustration of associative relationships among concepts in the semantic network discussion representation (Jonassen 1992; McAleese 1990). As stipulated by the schema theory, knowledge is stored in the long-term memory as a network of information packets (schemata) (Rumelhart et al. 1972; Rumelhart and Ortony 1977). These schemata represent a dynamic and abstract data structure of generic concepts that guide the construction of mental models (Johnson-Laird 1983). They are viewed as semantic networks or meaningfully related concepts (Jonassen and Reeves 1996). These networks are dynamic in the sense that they are continuously reconstructed through knowledge acquisition. The schema theory defines knowledge acquisition as the process of interpretation of new information and its assimilation and accommodation into schemata (Anderson and Pearson 1984). Assimilation is the incorporation of new information into an already existing schema whereas accommodation refers to the modification of an existing schema to fit in new information. In the context of computer-mediated discussions, a participant acquires knowledge by reorganizing his/her individual knowledge structure, reforming new schemata similar to that of the group (Shavelson 1974). The explicit mapping of collective knowledge onto the semantic networks discussion representation enables the individual participant to acquire the collective knowledge structure by providing a framework for the interpretation of the new collective knowledge and its integration with an existing individual knowledge structure.

A similar premise can be drawn from Mayer's (1979) information organization framework, which asserts that information organization and presentation affect the retention of knowledge. Knowledge acquisition can be enhanced when clues are available. With their underlying meanings, clues support better integration of knowledge in a macrostructure. For semantic network discussion representations, these clues take the form of network-based structure with links and cross-links, which represent meaningful relationships between concepts. Using links and cross-links, the semantic relationships among concepts are explicitly depicted (Al-Qaimari et al. 1994). They enable referential branching (Shackelford et al. 1993) that is consistent with the associative nature of the human mind (Chou 1999; Jonassen 1992; Kitajima et al. 2000; McAleese 1990). By providing support for the explicit conceptualization of the discussion, semantic networks help the participants to reach higher levels of understanding (Fisher 1992) and better knowledge integration (Mayer 1979), enhancing in this way knowledge acquisition.

Another important feature of the semantic network discussion representation is that it allows for different levels of prior knowledge (Stanton and Stammers 1990). With linear discussions, the user may have to go through irrelevant or known concepts sequentially before reaching the intended one. With a semantic network structure, new participants can quickly identify and directly access the discussion element of interest (Al-Qaimari et al. 1994). They can also actively explore the discussion at different levels of detail and complexity according to their own preferences and abilities (Nielsen 1990; Wang and Rada 1998). Compared to the rigid and passive navigation in linear discussion representation, the flexibility of semantic network navigation facilitates the exploration process, which has been reported to be highly effective in enhancing knowledge acquisition (Al-Qaimari et al. 1994; Gaines and Shaw 1992).

A shared context is another key condition for knowledge acquisition in group discussions (Kaiser and Bostrom 1982). To acquire knowledge from group discussions, individuals first must be able to develop shared understanding among themselves. Shared understanding is characterized by the absence of misinformation and misinterpretation in the interaction process. The establishment of shared understanding requires a state where "some sort of exchange by which the meaning of one person is made to correspond to an already existing meaning of another person" (Grossberg 1982, p. 173). In other words, shared meaning occurs when other participants interpret the message in the way intended by the contributor. To establish shared meaning and hence knowledge acquisition, a shared context must exist (Kaiser and Bostrom 1982).

A context refers to the domain or background in which knowledge is articulated or understood (Fischer et al. 1995). Ambiguities arise when the group fails to share the context in which the message is intended to be interpreted by the contributor. The clarity of interpretation can be enhanced with an explicit context (Kintsch 1988). Such explicit representation provides referential anchoring for the group to attain a common ground (e.g., mutual beliefs and knowledge) for the intended interpretation of the knowledge (Clark and Brennan 1991). Contextualization is of particular importance for discussion involving complex issues (e.g., non-routine situations), where misunderstanding is likely to occur (Daft and Lengel 1984; Te'eni 2001). For computer-mediated discussions, contextual information refers to meta information that can facilitate the interpretation of the exchanged information. Linear discussion forums usually provide environmental contextual information in the form of authorship and temporal attributes (i.e., information about the author of the contribution and its timing). They offer limited domain contextualization through the association of the new contribution to an existing one (i.e., threading). Semantic network discussions, on the other hand, enable contextualized access to domain knowledge through explicit representation of relationships among concepts. This feature has also been shown to be effective in enhancing understanding, reducing cost of knowledge acquisition, and resolving comprehension difficulties (Mao and Benbasat 1998). There is ample empirical evidence demonstrating the effect of contextualization on increased knowledge acquisition (Tyre and von Hippel 1997).

Drawing on the schema theory (Rumelhart et al. 1972) and the information organization framework (Mayer 1979), we expect that the explicit mapping of the participant contributions onto the semantic network structure will facilitate the acquisition of the embedded knowledge by the participants. Accordingly, we hypothesize that

> H_1: Semantic network discussion representations help participants to acquire significantly more complex and better integrated knowledge structures than do linear discussion representations.

Effect of Conceptual Facilitation Restrictiveness on Knowledge Acquisition

The levels of conceptual facilitation restrictiveness range from low to moderate and high, each presenting advantages and limitations. When the level of conceptual facilitation restrictiveness is high (which we label the totalitarian mode), the facilitator is imposing a specific mental model, his own, to the conceptualization of the discussion. High restrictiveness could enhance focus and provide direction, but would enforce the view of a particular facilitator constraining conceptualization. The moderate restrictiveness level (which we label the democratic mode), on the other hand, may favor the emergence of a collective mental model. With a lower level of restrictiveness (which we label the anarchist mode), no one single conceptualization is adopted. Rather, the resulting discussion network represents a web of individual mental models. Low restrictiveness allows for idea generation, but with the risk of compromising efficiency and quality.

Previous studies suggest that the effect of facilitation restrictiveness level differs across contexts. For example, the effects of process restrictiveness on discussion outcomes are reported as positive for decision making (Wheeler and Valacich 1996) and negative for knowledge sharing (Khalifa et al. 2002). In the context of knowledge acquisition, content facilitation is often shown to have little if any influence. The significance of its effect may vary a great deal depending on the quality and currency of the facilitator's contributions. Process facilitation, on the other hand, may favor the acquisition of more complex knowledge structures when it is less restrictive. This result is supported by the collaborative learning theory, which asserts that individual freedom should be allowed in the way knowledge is acquired (Khalifa et al. 2002). We expect a similar logic to apply to conceptual facilitation restrictiveness as well.

Our view is consistent with the central notion of the constructivist epistemology, which stipulates that knowledge acquisition is an active, constructive, and generative process involving assimilation, augmentation, and self-reorganization (Norman and Draper 1986; Papert 1993; Vygotsky 1978). In other words, knowledge cannot be transmitted from experts, but is rather acquired through the active engagement of the individual in the conceptualization of the knowledge (Tippins et al. 1993). In semantic network discussions, the collective mental model of the participants is explicitly represented, providing a framework for the interpretation of the exchanged information. Such explicit depiction of the interrelationships among concepts supports active construction of individual knowledge, enabling the individual mental models of the participants to be more structurally similar to the collective mental model (Royer et al. 1993). In other words, the explicit conceptual framework represented in semantic networks helps participants to integrate the collective knowledge into their existing individual knowledge structures. Notably, such an integration process is entirely individual-specific, as each participant has different prior knowledge. Some individuals have more complex and interconnected knowledge structures than others, hence requiring different ways of internalizing collective knowledge into their individual knowledge (Derry 1990). A too restrictive framework, whereby a facilitator imposes his own mental model on the *structure* of the discussion, may not be fully compatible with the individual's mental model, hindering the internalization of the externalized collective knowledge. With lower conceptual facilitation restrictiveness, on the other hand, the collective discussion framework is more freely structured by the participants. No intervention is imposed by the facilitator. The participants may structure the framework in a way that they consider compatible with their individual knowledge structures. The resulting discussion framework should, therefore, provide better support for the assimilation of the collective knowledge structure into individual knowledge structures.

Further support for our argument is drawn from the collaborative learning theory, which asserts that participants enjoy idea exchanges when they are given a nonthreatening and liberated environment in which to participate (Leidner and Fuller 1997). Bentley (1994) specifies that a key condition for knowledge acquisition is the availability of opportunities for the participants to go in the direction at their own free will. Casey et al. (1992) also suggest that appropriate facilitation for knowledge acquisition should enable participants to "work it out for themselves." Consistently, their arguments imply that aower level of conceptual facilitation restrictiveness results in higher knowledge acquisition. We therefore hypothesize that

> H_2: Conceptual facilitation restrictiveness is negatively related with complexity and integration of knowledge structures acquired by the participants.

Methodology

The empirical evaluation of our conceptual framework involved a field experiment with senior business students. Participation was completely voluntary and remunerated. Out of 140 students, 80 opted to take part, implying a participation rate of 57 percent. The p articipation was motivated by the similarity of the experiment to the students' natural learning setting. The 80 subjects were randomly assigned to three experimental groups and one control group with an equal group size of 20 each.

The subjects were familiar with the experimental task type, as they routinely engaged in computer-mediated discussions to discuss business cases as part of the requirements of the course in which they were enrolled.

All three experimental groups used a prototype web-based system with a semantic network discussion representation. The control group, on the other hand, used *Group System V*, which relies on a linear discussion representation. With the prototype discussion system used by the experimental groups, the discussion is represented graphically as a network. Concepts are represented by nodes while their direct/indirect interrelationships are denoted by links/cross-links. Before making a contribution, the subjects had to determine the concept (node) or the relationship (link/cross-link) where it belonged. If the intended concept or the relationship did not exist, the subjects could create the required node or link. The new nodes or links remained temporary until finally validated based on one of three possible modes of conceptual facilitation,: (1) the anarchist mode with the lowest restrictiveness; (2) the democratic model with moderate restrictiveness; or (3) the totalitarian mode with the highest restrictiveness. The experimental groups were randomly assigned to use one of these modes.

For the anarchist group, concepts and propositions contributed by the subjects were automatically accepted. For the democratic group, concepts and propositions were collectively validated by means of a voting feature of the prototype system. To vote, the subject needed to select the concept or proposition of interest and to click on the "vote" button. This triggered a popup showing a five-point Likert scale ranging from "strongly agree" to "strongly disagree." The cut-off point was determined at the creation of the discussion forum. Finally, for the totalitarian group, the acceptance of newly created concepts and propositions was fully restricted by the discussion facilitator, the teacher.

The task consisted of a computer-mediated group discussion of a business case. The subjects were asked to apply a number of frameworks studied in previous lectures to discuss the strengths and weaknesses of the given business model and suggest improvements. To alleviate possible evaluation apprehension effects, participant contribution was anonymous.

Measurement

Knowledge acquisition was operationalized as the complexity and level of knowledge integration using concept-mapping techniques (Novak and Gowin 1984). A concept map is a graph composed of propositions that form semantic units. Each semantic unit consists of a subset of concept nodes interconnected to one another by relational links (Chen et al. 2001), forming a hierarchy of concepts going from a higher level of abstraction (i.e., general concept), to lower levels (i.e., specific concepts, examples, objects, and events). Direct links relate concepts that belong to the same hierarchy. They are useful for defining general concepts in terms of specific concepts. Cross-links, on the other hand, relate concepts from different hierarchies and are useful for representing relationships between different concepts. Concept maps are widely accepted as explicit representations of integrated knowledge networks (Jonassen et al. 1993; Tan 2000).

During the experiment, the subjects were given a list of concepts relating to the case discussion and were asked to create as many meaningful relationships as possible between the given concepts. All relationships had to be labeled with propositions indicating their meanings. The proposed relationships could be of two types: direct links and cross-links. The knowledge acquired, as represented by the proposed relationships, can be characterized by its complexity and its level of integration (i.e., interconnectedness). The total number of valid direct links measures knowledge complexity while that of valid cross-links measures knowledge integration. The validity of these measures was verified by Khalifa and Kwok (1999). The proposed links were independently assessed by two experts. Individual scores were obtained by averaging the scores rated by these two experts.

Experimental Procedure

The experiment involved two stages performed on two different days. The first stage consisted of a 2-hour training session on concept mapping followed by a pre-treatment test. The training session included a 30-minute presentation and a 90-minute practice. The pre-treatment test was conducted after a 15-minute recess. It assessed the ability of the subjects to represent their knowledge with concept maps and checked for possible group differences. No significant group differences were detected. In this test, the subjects were asked to study a business case for about 30 minutes. They were then given an additional 30 minutes to develop a concept map describing the case without referring to the materials. No subjects reported difficulties in constructing concept maps and no significant group differences in terms of structural similarity of the maps were identified.

In the second stage of the experiment, the subjects participated in a computer-mediated discussion session. The case was different from the one used in the first stage. The computer-mediated discussion session lasted 45 minutes. After a short break of 15 minutes, the subjects were given 30 minutes to draw a concept map describing the concepts in the case. The durations of the discussion and concept mapping sessions were determined by a pilot experiment. To motivate performance, the subjects were informed in advance of a monetary prize of $200 for the "best" concept map.

Results

ANOVA was used to test the significance of the main effect of the treatment (semantic network discussion representation with multiple levels of conceptual facilitation restrictiveness) on the dependent variables (i.e., knowledge complexity and integration). All assumptions for ANOVA were verified, including the homogeneity of variances, as indicated by the Levene's test (Levin 1999). The ANOVA results confirm all of our hypotheses.

As illustrated in Table 1, the F-tests detected significant effects of the treatment on all dependent variables at the 99 percent level: complexity (F = 10.24) and integration (F = 11.18). These results demonstrate that the model is significant, hence enabling the applicability of multiple comparisons for mean differences.

The differences of the complexity and integration scores between the experimental groups and the control group were verified by a Dunnett t-test, which is considered as an effective test for comparison between each experimental group mean with the mean of the control group (Dunnett 1955). The mean scores for all dependent variables are significantly higher in the three experimental groups than the control group at the 95 percent level (see Table 2). These results indicate that the semantic network discussion representation leads to the acquisition of a higher level of knowledge complexity and integration than the linear discussion representation, confirming H_1.

We further compared the effects of conceptual facilitation restrictiveness by conducting a Bonferroni test (Klockars and Sax 1986), which examines the mean score differences of the three experimental groups, involving different levels of conceptual facilitation restrictiveness. The results (see Table 3) indicate that the anarchist group (representing low restrictiveness) yields significantly higher scores for both complexity and integration than the totalitarian group (representing high restrictiveness). While the scores of the anarchist group were also higher than those of the democratic group (representing moderate restrictiveness), such difference was not significant. Similarly, the democratic group did not achieve significantly higher complexity and integration than the totalitarian group. In other words, notable differences of performance in complexity and integration were only observed between the anarchist and totalitarian groups, implying that the effect of conceptual facilitation restrictiveness on knowledge complexity and integration only becomes significant when being compared in extreme cases (highest versus lowest restrictiveness). This result suggests that more complex and better integrated knowledge structures can be acquired with the relaxation of restrictiveness. As hypothesized in H_2, the less restrictive the conceptual facilitation, the more complex and better integrated the knowledge structure that can be achieved.

Table 1. ANOVA Results

	DF	F ratio	Significance (p)
Complexity	1	10.24	0.00
Integration	1	11.18	0.00

Table 2. Mean Differences of Complexity and Integration (Experimental Groups Versus Control Group)

	Semantic Network Discussion Representation (i)	**Linear Discussion Representation (ii)**	**Mean Difference (i) – (ii)**	**Standard Deviation**	**Significance (p)**
Complexity	Anarchist	Control	2.50	0.45	0.00
	Democratic	Control	1.40	0.45	0.00
	Totalitarian	Control	1.10	0.45	0.02
Integration	Anarchist	Control	2.05	0.36	0.00
	Democratic	Control	1.30	0.36	0.00
	Totalitarian	Control	1.05	0.36	0.01

Table 3. Mean Differences of Complexity and Integration (Within-Experimental Group Comparison)

	Mode of Facilitation Restrictiveness (i)	Mode of Facilitation Restrictiveness (ii)	Mean Difference (i) – (ii)	Standard Deviation	Significance (p)
Complexity	Anarchist	Democratic	1.10	0.45	0.11
		Totalitarian	1.40	0.45	0.17
	Democratic	Totalitarian	0.30	0.45	1.0
Integration	Anarchist	Democratic	0.75	0.36	0.24
		Totalitarian	1.00	0.36	0.04
	Democratic	Totalitarian	0.25	0.36	1.0

Conclusion

In this study, we investigate the effect of discussion representations on knowledge acquisition in computer-mediated discussions at three different levels of conceptual facilitation restrictiveness. We develop and operationalize conceptual facilitation as a new dimension of facilitation arising from the application of semantic network discussion representation, distinguishing between the anarchist (low restrictiveness), the democratic (moderate restrictiveness), and the totalitarian (high restrictiveness) levels. Using a field experimental study with 80 subjects, we empirically demonstrate that semantic network discussion representations provide better support for acquisition of more complex and integrated knowledge structures at all levels of conceptual facilitation restrictiveness. The effect of conceptual facilitation is, on the other hand, contingent upon its restrictiveness level. Significant increase (decrease) in the acquisition of complex and integrated knowledge structures is observed with the least (highest) restrictiveness. These results provide important implications for future research and practice.

A significant theoretical implication of our study is the importance of consideration of discussion representation in explaining group processes and outcomes in general and knowledge acquisition in particular. Theories of computer-mediated discussions need to be enhanced further with the construct of discussion representation. Our results support the arguments of several researchers calling for the development of contingency theories to resolve inconsistencies reported in prior studies. Our findings clearly demonstrate that discussion representation is another important contingency that needs to be taken into consideration. Future research should shed more light on the moderating effects of discussion representation on various group processes and outcomes. For example, future research can examine how semantic discussion representations alter the effects of computer-mediated discussions on convergence and reaching consensus.

Another theoretical implication of our study is the establishment of a new dimension of facilitation (i.e., conceptual facilitation), highlighting its significant role in the context of knowledge acquisition. To our knowledge, conceptual facilitation has never been considered in prior studies on computer-mediated discussions. Our results open the way to a new stream of research on conceptual facilitation. New modes of conceptual facilitation need to be investigated and the appropriate levels of restrictiveness for different contexts (e.g., knowledge sharing, decision making) should be determined.

On the practical side, our study presents significant implications to the advancement of computer-mediated discussion technologies by demonstrating the important role of discussion representation. Most traditional discussion forums feature liner representations. With the proliferation of computer-mediated discussion applications for supporting knowledge sharing and knowledge acquisition (e.g., communities of practice, online learning, knowledge portals, etc.), linear representations may no longer be adequate. Our study provides practitioners with evidence for the potential of semantic network discussion representations for knowledge centric applications. It also offers a proof of concept for the implementation of such discussion representations. Another important practical implication is related to the importance of conceptual facilitation. Our results highlight the need for flexible levels of restrictiveness, especially for knowledge acquisition applications (e.g., collaborative learning). Future research should investigate the effects of conceptual facilitation restrictiveness in other settings (e.g., decision making), as different levels of restrictiveness may be needed for different contexts.

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