Concept Maps: Making Learning Meaningful
Proc. of Fourth Int. Conference on Concept Mapping
Viña del Mar, Chile, 2010

THE ADDED VALUE OF COMMUNICATION IN A CSCL-SCENARIO COMPARED TO JUST HAVING ACCESS TO THE PARTNERS' KNOWLEDGE AND INFORMATION

Tanja Engelmann, Knowledge Media Research Center, Tuebingen, Antonia Baumeister, Chemnitz University of Technology,

Agnes Dingel & Friedrich Hesse, Knowledge Media Research Center, Tuebingen Germany

Email: t.engelmann@iwm-kmrc.de

Abstract. According to Wegner's theory of transactive memory system, in order to be able to collaborate effectively group members should both know which member knows what and communicate with each other. Sometimes, however, communication could also deteriorate group performance. Therefore, in this paper, a study is presented investigating whether it is sufficient for computer-supported problem solving to have direct access to the representation of externalized knowledge and information of the other group members by means of digital concept maps or whether communication with the other group members is also needed. In an empirical study (N = 81) triads with spatially distributed group members, that both had access to the externalized knowledge and information of the others and could communicate with each other, were compared to a condition in which the participants just had access to the knowledge and information of the others without the possibility to communicate. Results show that it is not sufficient just to have access to the knowledge and its underlying information of the others: Communication resulted in fewer mistakes in the problem-solving process, a superior performance in a complex problem-solving task, and communicating group members felt less stressed during problem solving compared to the condition without communication.

1 Theoretical Background

Research over several decades now has addressed the question whether groups perform better than individuals. The findings suggest that this is highly dependent on the task, its context (e.g., timely requirements), the individual skills as well as the medium or media applied to accomplish the task (e.g., Benbunan-Fich & Hiltz, 1999; Propp, 2003). For example, research has shown that groups perform better than individuals when both the group members have unshared task-relevant knowledge, that is, task-relevant aspects the other group members do not know yet, and they are willing and able to integrate this knowledge (e.g., Hollingshead, 2001). However, research on information sampling has consistently shown that groups are often biased to focus on knowledge that is shared by all members compared to unshared knowledge (e.g., Stasser & Titus, 1985). According to Franz and Larson (2002) group members are more likely to share their unshared knowledge if the expertise of each group member is known among each other. This points to the importance of communication within groups.

The described research implicates that groups work successfully if the group members share their unshared information, that is, if every group member knows all the task-relevant information aspects. This leads to the question whether a group member who knows all (shared and unshared) task-relevant knowledge elements still needs the others for solving the task or whether s/he is able to solve the task by herself/himself. However, learners can become cognitively overloaded if they have to handle too much information: Information beyond a specific high amount exceeds the individual's processing capacity resulting in performance decline (e.g., Eppler & Mengis, 2004). With increasing information load, it becomes increasingly difficult for example to identify and select relevant information. Information overload, thus, leads to more errors (Sparrow, 1999) and less accurate decisions (e.g., Malhotra, 1982).

This is in line with Wegner's (1986) theory of transactive memory system. According to Wegner, in a group it is not necessary to share all task-relevant information, but it is enough to know who knows what. Moreover, knowing who the experts in a group are improves group memory performance. He defined a transactive memory system as "a set of individual memory systems in combination with the communication that takes place between individuals" (Wegner, 1986, p. 186). Accordingly, communication between the group members plays an important role for the functioning of transactive memory systems because it supports, for example, getting to know who the experts are in a group (Wegner, 1986).

However, communication is not always helpful: For example, brainstorming research found that communication during memory retrieval can produce interferences with individual retrieval strategies (e.g., Diehl & Stroebe, 1991). According to Pavitt (2003) communication, especially with growing group size, does not result in optimal information sampling. Communication therefore seems to be at times helpful or even necessary (e.g., in order to exchange unshared task-relevant information), but it could also increase cognitive demands in a way that affects performance negatively (e.g., Dillenbourg & Bétrancourt, 2006): Following Dillenbourg and Bétrancourt, collaboration – and therefore also communication – can decrease individual cognitive load if some degree of division of labour is established. However, they also constituted that collaboration also creates additional cognitive demands, for example, due to the need to express one's own thoughts or to try to understand each other.

To sum up, groups perform better than individuals if both they have to consider and do consider task-relevant unshared information while solving a task. This group advantage is caused by the distribution of the task-relevant knowledge among the group members that reduces individual cognitive load. As described, however, communication on the one hand is important for information exchange during group problem solving, but on the other hand, it may also increase an individual group member's cognitive load. This leads to the following assumptions: (1) Is communication between learners in a typical computer-supported collaborative learning (CSCL) situation, in which the spatially distributed group members have to solve problems together by means of computer support, a hindrance to their collaboration? In this case, it would have to be expected that individuals who have been provided with all task-relevant (shared and unshared) knowledge elements not leading to cognitive overload, should perform the task as effectively or even more effectively than groups, because they do not have to communicate. The question is whether it is possible to provide individuals with all task-relevant knowledge elements without causing cognitive overload. There is a great deal of empirical evidence that especially visualizations may reduce cognitive load (e.g., Sweller & Chandler, 1994) and serve as a basis for externalized cognition (e.g., Scaife & Rogers, 1996). Therefore, it can be assumed that access to visualizations of the externalized knowledge of other group members could be an efficient way for individuals to solve problems as effectively or even more effectively as the groups with unshared knowledge, which we have described above, on the assumption, of course, that communication does indeed decrease group performance. An example of such corresponding visualization is the knowledge and information awareness tool by Engelmann and colleagues (e.g., Engelmann, Tergan, & Hesse, 2010; Engelmann & Hesse, 2010). They defined knowledge and information awareness as being informed with regard to both the knowledge and its underlying information of the collaboration partners. A typical tool for fostering knowledge and information awareness is a computer-supported representation of externalized knowledge structures and the underlying information of the partners by means of digital concept maps (e.g., Engelmann et al., 2010; Engelmann & Hesse, 2010). Having access to this kind of tool, the individual does not have to keep all information in mind. If members want to know something, they can easily check it out in the collaborators' maps. This is accordant with the principle of the transactive memory system, but without the need to communicate with the others. (2) If communication is indeed helpful in a typical CSCL situation, groups will outperform even those individuals who have access to the knowledge elements of their partners without being cognitively overloaded.

2 Experimental Study

In this empirical study it is investigated whether in virtual groups it is sufficient to know what the collaborators know and to which information resources the others have access (i.e., to have knowledge and information awareness), in order to be able to solve problems effectively, or whether the possibility to discuss with spatially distributed group members and thus, to collaborate, is also needed. To answer this question, we compared a control condition - in which the group members were only informed with regard to their cooperation partners' knowledge and underlying information, but could not communicate with each other - with an experimental condition in which the group members were both informed with regard to the others' knowledge and information as well as able to communicate and collaborate with each other.

According to the results of the study of Engelmann et al. (2010) and the study of Engelmann and Hesse (2010) it can be assumed that the availability of a tool for fostering knowledge and information awareness in fact enhances knowledge and information awareness. However, it can be expected that having the possibility to discuss contents with others will also contribute to the enhancement of knowledge and information awareness. Therefore, we propose the following:

- Hypothesis 1: The experimental condition will acquire more knowledge and information awareness compared to the control condition, because in the experimental condition there are two possibilities to foster knowledge and information awareness, namely being informed with regard to the others' knowledge and information via the tool applied and being able to discuss their knowledge and information among each other.

Having the possibility to generate more knowledge and information awareness and to clarify ambiguous aspects should have a positive impact on problem-solving activities:

- Hypothesis 2: The experimental condition will create digital concept maps, containing the structured task-relevant aspects that are more suited for solving the problems compared to the maps created by the control condition.
- Hypothesis 3: Therefore, the experimental condition will be more successful in solving the problems compared to the control condition.

3 Method

3.1 Participants

Participants were 81 university students (53 female, 28 male) of different fields of study. The average age was 23.60 years (SD = 3.25). The students were randomly assigned to 20 triads in the experimental condition and 21 simulated triads in the control condition. Each triad in the experimental condition consisted of an expert a, an expert b, and an expert c (N = 60). In the control condition, each participant was also randomly assigned to the role of expert a, b, or c, resulting in seven experts named a, b, and c. In the control condition, however, the two partners of the participant were simulated. There was no significant sex difference between the two conditions.

3.2 Materials and Procedure

In the experimental condition, the participants worked in groups of three students, each sitting in a separate room. In the control condition, the participants worked alone each sitting also in his/her own room. Each of the rooms was equipped with a desktop computer. In the problem-solving phase, group members of the experimental condition could communicate with each other by using Skype, a free internet phone software. In the control condition, the participants did not have the possibility to communicate with the others. The experimental environment was realized by using CmapTools, a digital concept mapping software developed by the Florida Institute of Human and Machine Cognition (USA).

The experimental environment used in this study provided information elements that are necessary for the rescue of a fictitious kind of spruce forest. These information elements consisted of 13 concepts, 30 relations between these concepts, and 13 (task irrelevant) background information elements, and were evenly distributed among the three group members in the experimental condition and among the three assumed group members in the control condition. Each participant had access to several concepts, relations, and background information that were unshared, shared with one (assumed) collaborator, or shared with both (assumed) collaborators.

The participants started with an online test aimed at assessing control variables, such as experience with computers, mapping techniques, and group work. Afterwards, they practiced using the applied software CmapTools until they could handle it without any problems. After practicing, they started with individual phase 1 of the experiment. At the outset of this phase, participants were told that they are experts who have to protect a spruce forest and that they first have to "refresh" their domain expertise before they start to collaborate to find a common solution for the problems. During this individual phase 1, which lasted 10 minutes, each group member was provided with her/his own digital concept map showing the conceptual knowledge (i.e., concepts and relations) and background information (underlying the conceptual knowledge), they had to refresh. In the individual phase 2, each participant had 5 minutes to view her/his own map as well as the maps of her/his (actual or assumed) collaborators.

After this activity, the participants were asked to fill out a paper-pencil questionnaire containing 15 multiple choice items to measure whether they had already acquired knowledge and information awareness. Subsequently in the problem-solving phase, the participants had to solve two problems, that is, which pesticide and which fertilizer they would use to protect and to cultivate the spruce forest. They had to start with the pesticide problem, because only if the correct solution was chosen, the fertilizer problem could be correctly solved, that is, the fertilizer problem was based on the pesticide problem. The participants were told that they should start with the pesticide problem and that there was only one possible correct solution for each problem. In the experimental condition, to solve these problems collaboratively, the group members needed to compile the knowledge and information that they had refreshed in the individual phase 1. To do this, they used a shared working window to create a mutual digital concept map containing the knowledge and information they were provided with in the individual phase. During this phase, they could speak with each other. In the control condition, the participants were informed that their collaborators were recalled short-term in order to solve another urgent problem. Therefore, the participants were told to solve the two problems without the others. However, they had access to the knowledge and information resources of the collaborators, that is, they could use the digital concept maps of the others. Both conditions had 40 minutes for solving the problems. In both conditions, the participants could see their own working window, the shared working window, as well as the individual maps of their (assumed) collaborators; that is, they were provided with a tool fostering their awareness regarding the externalized knowledge and its underlying information of their (assumed) collaborators (Figure 1).

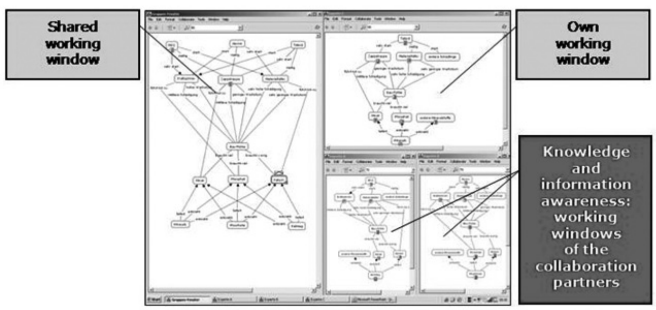

Figure 1. Screen in the problem-solving phase

After this problem-solving phase, the participants were given another test to measure their knowledge and information awareness. In this test phase, the experimental environment was no longer available. There were no time limits on this test. At the end of the study, participants worked on a questionnaire to evaluate the study regarding, for example, difficulties in using CmapTools or the need to communicate or collaborate with others.

3.3 Design and Dependent Measures

The analysis was based on a statistical comparison of the experimental condition and the control condition. In the experimental condition, the participants were not only provided with a tool for fostering knowledge and information awareness, they were also able to communicate with the others about the contents of the environment. In the control condition, the group members were also provided with a tool for fostering knowledge and information awareness, but they were not able to communicate with the others. In order to be able to compare the group values of the experimental condition and the values of the simulated groups of the control condition, in the experimental condition, the group means were calculated for each variable resulting in 20 group values for each measurement; in the control condition, the individual values were used. The reason for choosing this method of analysis is based on the main output level: The groups in the experimental condition created one common concept map as well as two common problem-solving solutions, while in the simulated groups, each individual participant also created one concept map and two problem-solving solutions. Therefore, the main output for each of the two conditions could be compared directly. An alpha level of .05 was used for all statistical tests. The dependent measures were:

3.3.1 Test of Knowledge and Information Awareness After the Problem-Solving Phase

The test consisted of 36 multiple-choice items. The items were classified among others with regard to who possessed the knowledge or information asked for (i.e., whether only oneself, only one of the (assumed) collaborators, oneself and one of the (assumed) collaborators, or only both (assumed) collaborators possessed the data). However, regarding the knowledge and information awareness concept, only the categories “only one of the (assumed) collaborators possessed the data” (max. 14 attainable points) and “only both (assumed) collaborators possessed the data” (max. 9 attainable points) are relevant. For each correct answer one point was given.

3.3.2 The Quality of the Created Concept Map

In order to analyze the quality of the created maps, the maps were compared to an expert's map. Five dependent variables were assessed: the number of correct nodes (max. 13 attainable points), the number of correct relations (max. 30 attainable points), the number of wrong nodes (no limit regarding attainable points), the number of wrong relations (no limit regarding attainable points), and the number of (task irrelevant) background information (max. 13 attainable points). For each entry of each category one point was given.

3.3.3 The Quality of the Answers to the two Problem-Solving Tasks

In this context, it was differentiated between the correctness of a solution and the correctness of the reasons given for a correct solution. The reasons given by the groups in the experimental condition and the individuals in the control condition were compared to the reasons given by an expert response. For each correct solution, one point was given. Only if the correct solution was found, the reasons given were analyzed according to an analysis schema with 0 points for a completely wrong answer and up to 3 points for a completely correct answer. Whenever the solution was wrong, zero points were given for the reasons. Two independent raters analyzed the reasons given by the groups. The interrater agreements were calculated: Regarding the reasons given as to why they chose the correct pesticide, Cohen's kappa was $\kappa = 0.86$ (cf. Cohen 1960). With regard to the reasons given as to why they chose the correct fertilizer Cohen's kappa for interrater agreement was $\kappa = 0.93$.

3.3.4 Subjective Evaluation of Study Aspects

The questionnaire contained five-point rating scale items ranging from 1 for no agreement to 5 for complete agreement concerning the evaluation of the study and the use of CmapTools. In the experimental condition, the communication and collaboration was evaluated; in the control condition, it was asked whether it would have been helpful to be able to communicate or collaborate with others. Due to the differences concerning the communication possibility between the conditions, there were 51 items in the experimental condition and 60 items in the control condition.

3.3.5 Manipulation Check

As a manipulation check at the end of the study, we asked participants in the control condition by means of a 5-point rating scale item, ranging from 5 points for complete agreement and 1 for no agreement, if they thought at beginning of the experiment that this was a study in which they had to cooperate with others.

4 Results

With regard to the 25 control measure items (e.g., experience in group work), a factor analysis with Varimax rotation was conducted resulting in 3 interpretable factors with eigenvalues higher than 1. The factors were called "Experience with Concept Maps", "Preferences Regarding Group Work", and "Experience in Working with Computers". For each of these factors a univariate ANOVA was performed showing that there were no significant differences between the two conditions. Therefore, the inclusion of a covariate was not necessary.

Partial eta-squared values ($\eta p2$) as a descriptive index of strength of association between the experimental factor and a dependent variable are reported in this paper (Cohen, 1973). Such a value is defined as "the proportion of total variance attributable to the factor", excluding other factors' impact (Pierce, Block, & Aguinis, 2004, p. 918).

Regarding the analysis of the manipulation check item, we found that only 11 of the 21 participants in the control condition believed that this was a group experiment, while 7 participants did not believe it and 3 participants were undecided.

In contrast to our hypothesis 1, postulating that the experimental condition outperforms the control condition regarding the amount of acquired knowledge and information awareness, the analysis of the knowledge and information awareness test after the problem-solving phase did not show significant differences between the conditions (Information that only one of the others had: $F < 1$; Information that both of the others had: $MC = 6.9$, $ME = 6.2$, $F(1,39) =$

1.95, MSE = 2.43, $p > .05$).

Even though there was no difference on the amount of knowledge and information awareness between the conditions, significant effects were found in the problem-solving performance: With regard to the concept maps that had to be created in order to be able to solve the problems, the analyses showed that in the control condition, the created concept maps for solving the problems contained more wrong relations (MC = 4.67; ME = 1.25; $F(1,39) = 9.25$; MSE = 12.93; $p < .05$; $\eta p2 = .19$). This result is accordant to our hypothesis 2. However, there were no significant differences regarding the other concept map measurements.

The mistakes in the concept map seem to have an impact on the correctness of the problem-solving answers: The analysis of the problem-solving tasks showed indeed no significant differences regarding the correctness of the pesticide problem ($F < 1$) and the reasons given why this answer is chosen (MC = 1.57; ME = 2.1; $F(1,39) = 2.19$; MSE = 1.31; $p > .05$), however, regarding the fertilizer problem, the experimental condition outperformed the control condition with regard to the frequency of the correct solution (MC = 0.62; ME = 0.95; $F(1,39) = 7.41$; MSE = 0.15; $p < .05$; $\eta p2 = .16$) and with regard to the correctness of the reasons given as to why this answer was chosen (MC = 1.19; ME = 2.10; $F(1,39) = 10.00$; MSE = 0.85; $p < .01$; $\eta p2 = .20$). Here it should be noted that the fertilizer problem is a more complex problem compared to the pesticide problem because it builds on the pesticide problem; that is, it can only be solved correctly if the pesticide problem is done correctly. Our hypotheses 3 could thus be partly confirmed.

To analyze the questionnaire for evaluating different study aspects, a factor analysis with Varimax rotation was conducted. We found 3 interpretable factors with eigenvalues higher than 1. Univariate ANOVAs for each factor resulted in one significant difference between the two conditions: The participants in the experimental condition were more confident that they solved the problems correctly and they felt less stressed while participating in the study compared to the control condition (MC = -0.43; ME = 0.45; $F(1,39) = 9.43$; MSE = 0.83.; $p < .01$; $\eta p2 = .20$).

5 Summary and Discussion

According to Wegner's theory of transactive memory systems (Wegner, 1986), group members do not need to share all information, instead in groups it is sufficient to know who of the other group members knows what. However, he highlighted the importance of communication between the group members, for example, in order to establish a transactive memory system or to retrieve information saved in the group. Other areas of research, however, showed that sometimes communication can cause problems that lead to decreased group performance. In this paper, we investigated the role of communication in a situation in which the group members had direct access to a representation of the externalized knowledge and information of the other group members. We compared an experimental condition in which the spatially distributed group members were provided with the described representation and were also able to communicate with each other, with a control condition in which participants worked alone and had only access to this representation without being able to communicate with the others.

We expected that both the access to the externalized knowledge and information of the others as well as the communication foster knowledge and information awareness (i.e., being informed with regard to the knowledge and its underlying information of the collaboration partners). Therefore, we hypothesized that the experimental condition acquires more knowledge and information awareness compared to the control condition (see hypothesis 1). However, we found no difference between the conditions. Having the possibility to use the tool applied seems to be sufficient to acquire knowledge and information awareness. The additional possibility to communicate with the others did not result in an increased amount of knowledge and information awareness. This could be caused by a ceiling effect, that is, in this situation, the applied tool alone was sufficient to foster knowledge and information awareness. In addition, a reason could be that tools such as the applied one are, in general, efficient enough to foster knowledge and information awareness. Another explanation could be that in the control condition the participants were keen to acquire knowledge and information awareness, because they had to solve the task by themselves, whereas knowledge and information awareness was acquired casually in the experimental condition. This interpretation is corroborated by the result of the manipulation check showing that only slightly more than the half of participants in the control condition believed that this was a group experiment. Even though there were no significant differences regarding the acquired knowledge and information awareness, we found significant effects in performances: The participants of the control condition included more incorrect relations in their maps. This is accordant to hypothesis 2. Therefore, the possibility to communicate with others seems to reduce mistakes in the maps. This is in accordance with empirical findings of other former studies showing that group members tend to correct diverse types of errors mutually which improves their performance compared to individuals (e.g., Hinsz, 1990; Vollrath, Sheppard, Hinsz & Davis, 1989). The hypothesis 3 could be confirmed for the complex fertilizer problem: The possibility to communicate with others seems to have a positive impact on solving the complex task: We found that the experimental condition outperformed the control condition in the complex problem-solving task, but not regarding the easier task. This is in line with Hirokawa (1999), postulating that communication becomes particularly important if the structure of the problem-solving task is complex. This is also accordant to the findings of Wilson, Timmel, and Miller (2004) showing that interacting groups are superior to individuals if solving the tasks exceeds the capacity of individuals (Wilson et al., 2004). In addition, we found that the groups of the experimental condition felt less stressed and were more confident that their solutions were correct compared to the control condition. This may be explained by findings of other studies showing that collaborative learning and problem solving leads to more satisfaction compared to individual learning (e.g., Benbunan-Fich & Hiltz, 1999). These results lead to the conclusion that communication plays a crucial role for group performance. The findings show that it is not enough to be informed with regard to the others' knowledge and information, communication is also important.

It may be argued, however, that additional reasons were responsible for the superiority of the experimental condition over the control condition: The fact that participants in the experimental condition could communicate and, therefore, collaborate for solving the problems may have led to information processing characteristics or problem-solving strategies that differed from those of the participants of the simulated groups, that is, of the control condition. For example, groups can apply more effective decision-making strategies, because the members can provide various judgments that can be weighted differently (e.g., Vollrath et al., 1989). In our study, the group members of the experimental condition could suggest different solutions and could discuss which one could be correct. In the control condition, the participant could not communicate with the others and perhaps was not able to find or not willing to consider alternatives to her/his own solution. However, as already mentioned, collaboration could have also been a hindrance for group performance. Tindale and Sheffey (2002), for example, found in their experiment that collaboration did not improve group memory performance in terms of number of recalled items. The authors interpret this result in terms of production blocking and social loafing that may have occurred in the condition with interacting groups. Further studies are needed that investigate the role of collaboration if the group members are provided with a tool for fostering knowledge and information awareness. For example, the question should be answered whether information processing or problem-solving strategies of groups using a tool for fostering knowledge and information awareness differ from those of individuals who also have access to this tool.

To sum up, with the study described in this paper, we could show that although the group members had direct access to the externalized knowledge and information of the other group members and therefore had knowledge and information awareness, it was also necessary to be able to communicate with the others in order to perform effectively in complex problem-solving tasks.

6 Acknowledgements

This research project was supported by the Knowledge Media Research Center (KMRC) in Tuebingen (Germany). The first author is supported by the European Social Fund and by the Ministry Of Science, Research and the Arts Baden-Württemberg (Germany). We especially thank the Florida Institute for Human and Machine Cognition (USA) for providing CmapTools, as well as the Media Development Group of KMRC for their technical assistance.

References

Benbunan-Fich, R., & Hiltz, S. R. (1999). Impacts of asynchronous learning networks on individual and group problem solving: A field experiment. Group Decision and Negotiation, 8, 409-426.

Cohen, J. (1960). A coefficient of agreement for nominal scales. Educational and Psychological Measurement, 20(1), 37-46.

Cohen, J. (1973). Eta-squared and partial eta-squared in fixed factor ANOVA designs. Educational and Psychological Measurement, 33, 107-112.

Diehl, M., & Stroebe, W. (1991). Productivity loss in idea-generating groups: Tracking down the blocking effect.

Journal of Personality and Social Psychology, 61(3), 392-403.

Dillenbourg, P., & Bétrancourt, M. (2006). Collaboration load. In J. Elen and R. E. Clark (Eds.), Handling complexity in learning environments: Research and theory (pp. 142-163). Advances in Learning and Instruction Series, Pergamon.

Engelmann, T., & Hesse, F. W. (2010). How digital concept maps about the collaborators' knowledge and information influence computer-supported collaborative problem solving. International Journal of Computer-Supported Collaborative Learning, 5(3), 299-319.

Engelmann, T., Tergan, S.-O. & Hesse, F. W. (2010). Evoking knowledge and information awareness for enhancing computer-supported collaborative problem solving. The Journal of Experimental Education, 78, 1-20.

Eppler, M. J., & Mengis, J. (2004). The concept of information overload: A review of literature from organization science, accounting, marketing, MIS, and related disciplines. The Information Society, 20, 325-344.

Franz, T. M., Larson, J. R. Jr. (2002). The impact of experts on information sharing during group discussion. Small Group Research, 33(4), 383-411.

Hinsz, V. B. (1990). Cognitive and consensus processes in group recognition memory performance. Journal of Personality and Social Psychology, 59(4), 705-718.

Hirokawa, R. Y. (1990). The role of communication in group decision-making efficacy. A task-contingency perspective. Small Group Research, 21(2), 190-204.

Hollingshead, A. B. (2001). Cognitive interdependence and convergent expectations in transactive memory. Journal of Personality and Social Psychology, 81, 1080-1089.

Malhotra, N. K. (1982). Information load and consumer decision making. The Journal of Consumer Research, 8, 419-431.

Pavitt, C. (2003). Colloquy: Do interacting groups perform better than aggregates of individuals? Why we have to be reductionists about group memory. Human Communication Research, 29(4), 592-599.

Pierce, C. A., Block, R. A., & Aguinis, H. (2004). Cautionary note on reporting eta-squared values from multifactor ANOVA designs. Educational and Psychological Measurement, 64(6), 916-924.

Propp, K. M. (2003). In search of the assembly bonus effect: Continued exploration of communication's role in group memory. Human Communication Research, 29(4), 600-606.

Scaife, M. & Rogers, Y. (1996). External cognition: how do graphical representations work? International Journal of Human-Computer-Studies, 45(2), 185-213.

Sparrow, P. R. (1999). Strategy and cognition: Understanding the role of management knowledge structures, organizational memory and information overload. Creativity and Innovation Management, 8(2), 140-148.

Stasser, G., & Titus, W. (1985). Pooling of unshared information in group decision making: Biased information sampling during discussion. Journal of Personality and Social Psychology, 48(6), 1467-1478.

Sweller, J. & Chandler, P. (1994). Why some material is difficult to learn. Cognition and Instruction, 12, 185-233.

Tindale, R. S., & Sheffey, S. (2002). Shared information, cognitive load, and group memory. Group Processes and Intergroup Relations, 5(1), 5-18.

Vollrath, D. A., Sheppard, B. H., Hinsz, V. B., & Davis, J. H. (1989). Memory performance by decision-making groups and individuals. Organizational Behavior and Human Decision Processes, 43, 289-300.

Wegner, D. M. (1986). Transactive memory: A contemporary analysis of the group mind. In B. Mullen & G. R. Goethals (Eds.), Theories of group behaviour (pp. 185-208). New York: Springer.

Wilson, D. S., Timmel, J. J., & Miller, R. R. (2004). Cognitive cooperation: When the going gets tough, think as a group. Human Nature, 15(3), 225-250.