Collaborative learning in virtual seminars: Analyzing learning processes and learning outcomes

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Abstract: This paper focuses on the analysis of a virtual seminar in respect to learning processes and learning outcomes of its participants who collaborated over a four month period. To investigate the learning processes in this field study, we analyzed the learners’ contributions according to four main learning processes: epistemic activities, construction of a conceptual space, dissemination of shared knowledge, and conflict-orientation. To investigate the learning outcome, we analyzed the joint task solutions with respect to knowledge acquisition and knowledge application. Learners were assigned to three groups who had to solve four tasks relating to the main topics on knowledge management. Results show that learning processes varied depending on the tasks and groups, but no general trend was found. Furthermore, the four task solutions also differed in their quality. The fact that learning processes were related to group products confirms the relevance of learning processes for acquiring and applying knowledge.

Learning processes and outcomes in collaborative online learning
Collaborative learning in virtual asynchronous seminars is becoming increasingly common within university settings. From a social-constructivist perspective, collaboration is one important method for learning (Cohen, 1994). The assumption is that during collaboration, learners have to elaborate on their knowledge in more detail (Webb, & Palincsar, 1996), solve socio-cognitive conflicts which arise when learners have conflicting knowledge (Piaget, 1977), and exchange arguments about the best group solution (Andriessen, Baker, & Suthers, 2003). To evoke these positive effects of collaboration, it is necessary to design powerful learning knowledge (Piaget, 1977), and exchange arguments about the best group solution (Andriessen, Baker, & Suthers, 2003). To evoke these positive effects of collaboration, it is necessary to design powerful learning environments (De Corte, 2003). On a didactical level, such collaborative learning environments may include, for example, tasks which necessitate the interdependent collaboration of all group members (Johnson, & Johnson, 1992), groups with an appropriate number of members between 2 and 5 (Lou, Abrami, & d’Appollonia, 2001), or didactical design principles such as problem-based learning (Dochy, Segers, Van den Bossche, & Gijbels, 2003, Koschmann, Kelson, Felchtovich, & Barrows, 1996). This specifically involves four design principles which may help motivate learners in their learning processes: the integration of authentic problems that illustrate the relevance of the subject for real-life cases, multiple perspectives for showing different points of view, collaborative learning, and scaffolds to support learners in their knowledge acquisition (Reinmann, & Mandl, 2006). All of these design principles are relevant for both face-to-face and virtual collaboration even though there may be a few differences concerning the actual collaboration itself. Such differences mainly involve the method of communication, because the contributions in virtual environments are not spoken, but typed. Typing contributions may improve performance (Jonassen, & Kwon, 2001) for the following reason: Learners not only have more time to reflect on their own contributions, but may also reflect longer on the contributions of other group members – and this on a high level (Thomas, 2002). Therefore, contributions in virtual environments may be more detailed than those in face-to-face collaboration (Althaus, 1992). Due to this fact, virtual collaboration may facilitate deeper and more intensive learning.

To verify this assumption, it is necessary to have a closer look at specific learning processes and learning outcomes in virtual learning environments that involve knowledge acquisition as well as knowledge application (De Corte, Verschaffel, Entwistle, & van Merrienboer, 2003). The following cognitive activities are important for learning processes:

First of all, **epistemic activities** are a very important indicator of the learner’s level of concentration on task-relevant aspects (Fischer, Bruhn, Grasel, & Mandl, 2002). Learners in virtual learning environments are more involved than learners in face-to-face scenarios (Kiesler, & Sproull, 1992). Epistemic activities are mainly subdivided into content-specific and coordination-oriented processes (Bruhn, 2000). Learners who engage in elaborating and discussing the content and theoretical concepts they are confronted with should be better at acquiring and applying knowledge (Cohen, 1994). Coordination-oriented processes comprise all activities which are necessary for solving the task collaboratively while discussing and agreeing on the procedure. These activities are not necessarily beneficial for learning, but they are necessary if learners do not automatically know how to solve a task collaboratively. Studies on supporting computer-supported collaborative learning reveal that this is often the case (Fischer, Kollar, Mandl, & Haake, 2007).

A second aspect concerns the **construction of a conceptual space or problem space**, which is especially important in computer-supported collaborative learning (Teasley, & Roschelle, 1993). As Roschelle and Teasley
outcomes and their relationship to one another. Based on our theoretical considerations, there are three main questions concerning learning processes, learning outcomes and their relationship to one another.

The third activity, the dissemination of knowledge, is very closely related to the construction of a conceptual space. This is a key aspect of collaboration: Collaboration can only take place when knowledge is disseminated among the collaborating partners (Kopp, & Mandl, 2006). In this context, it makes sense to look more closely at the information pooling paradigm (Stasser, & Titus, 1985, Wittenbaum, & Stasser, 1996). This focuses on the phenomenon that group members often simply name and repeat shared information and do not disseminate unshared information. Even though it was assumed that virtual learning environments could compensate for such effects through collaboration, studies showed no difference between virtual and face-to-face collaboration (Hollingshead, 1996). Therefore, it is necessary to have a closer look at the knowledge disseminated in the learner’s contributions. But even this analysis alone may not prove sufficient, because even when learners disseminate knowledge, the knowledge is not necessarily considered and processed further as part of the task’s solution. This is due to learner’s preference-consistent evaluation of information (Greitemeyer, & Schulz-Hardt, 2003). Thus, consideration must be given to both the knowledge that is disseminated during collaboration and the knowledge that is integrated into the task solution.

A fourth learning activity is manifested in conflict-orientation. According to Piaget (1977), confronting different perspectives and knowledge stimulates learning as a result of socio-cognitive conflicts. Such conflicts may disturb the learner’s cognitive equilibrium. Learners then aim to restore this cognitive equilibrium again. One way of achieving this is through intensive cognitive processing that leads to local coherence and a deeper understanding of the subject matter (De Lisi, & Goldbeck, 1999). This approach focuses on the development and resolution of socio-cognitive conflicts. Doise and Mugny (1984) found that learners who are engaged in socio-cognitive conflicts provoked by critical statements elaborated their knowledge more deeply and were therefore more successful in acquiring knowledge. Both the number of socio-cognitive conflicts and their manner of resolution are important aspects of effective knowledge acquisition (Nastasi, & Clements, 1992).

Analyzing the group product in the form of the task solution is one main method of measuring learning outcome (Slavin, 1995). The group product shows how effectively and successfully the learners have collaborated. This indication of the learning success may be analyzed in different ways (De Jong, & Ferguson-Hessler, 1996). Cued and free recall provide one way of investigating the acquisition of conceptual knowledge (Reiserer, 2003). Another method involves using cases to analyze the application of situative knowledge (Fischer et al., 2002). Both knowledge acquisition and knowledge application are especially important when looking at group products in problem-based learning environments, (De Corte, 2003). Therefore, when analyzing group products as task solutions, both the learned concepts and their application to a specific problem are relevant. In this respect, the case analyses should include theoretical concepts and the quality of the case solution.

Both learning processes and learning outcomes may change during collaboration. The longer learners collaborate, the more they grow accustomed to it. This implies that learning processes and learning outcomes improve over time. More specifically, content-specific epistemic activities increase over time, while coordination-oriented activities decrease: when learners get used to collaborating, they know how to proceed and coordinate their activities. Therefore, they have more capacity to elaborate on content-specific aspects and spend less time discussing their coordination. Furthermore, the negotiation efforts surrounding a shared problem will improve as well as learner’s effectiveness in disseminating knowledge. The better the learners get to know each other, the less they fear offending other group members when counter-arguing or criticizing. Lastly, it is assumed that group products improve over time as a result of better collaboration.

Questions and hypotheses of the study
Based on our theoretical considerations, there are three main questions concerning learning processes, learning outcomes and their relationship to one another.

1) To what extent do learning processes occur in virtual seminars? It is assumed that learners will be highly involved in all four learning processes: epistemic activities, conceptual space, dissemination of shared knowledge and conflict-orientation. In addition, we hypothesize that they change and improve over time.

2) To what extent does the quality of group products change over time? Because learners gain experience in collaborating over time, we hypothesize that the quality of group products will improve during the course of the seminar.
Is there a relationship between the learning processes and the learning outcome in virtual seminars? We expect that learning processes and learning outcome are related: We expect to observe a positive correlation between collaborative learning outcome and content-specific epistemic activities (Cohen, 1994), conceptual space (Rochelle, & Teasley, 1995), shared knowledge (Rochelle, & Teasley, 1995), and conflict-orientation (Piaget, 1977).

Method

Sample and Design
The participants of the field study included the undergraduates of the University of Munich who were enrolled in the virtual seminar “Introduction to Knowledge Management” during the winter term 2002/2003. Eight females and five males were divided into three groups: two groups with four members and one group with five members. To help prevent the group members from meeting face-to-face, the groups were formed according to the residences that were furthest away from one another.

Learning Environment

Tasks
Learners who participated in this seminar had to collaborate with one another during the whole semester. Learners were mainly tasked with acquiring knowledge on the four topics of “knowledge representation”, “knowledge communication”, “knowledge generation”, and “knowledge use”. The tasks assigned were provided in the form of cases. Each case described problems that various companies faced relating to knowledge management. All cases were subdivided into two tasks: In the first task, learners were asked to collect the information provided on the topic (conceptual knowledge). In the second task, learners had to actively construct new knowledge by applying the knowledge acquired (situative knowledge). Each of the cases required a different method of analysis depending on the topic. In the case on “knowledge representation”, learners were to investigate the main problems relating to knowledge representation in organizations and search for different solutions. The case on “knowledge communication” provided a basis for identifying the functions and characteristics of knowledge communication as well as barriers to knowledge communication. Furthermore, learners had to define a concept for initiating a community of practice. The last case was conceptualized to encourage various methods of knowledge generation and their implementation. In the last case, a learning center had to be evaluated on the basis of the methods for knowledge use.

Didactics
The learning environment was didactically designed according to problem-based principles. These included the learner’s collaboration throughout the whole semester and the joint case solution. The cases were developed according to authentic knowledge management-related problems present in different companies. To additionally support learners in the virtual seminar, they received information on each topic and collaboration rules.

Technical Realization
The learning environment consisted of features such as a user interface or HTML-pages, and threaded discussion boards with the potential for users to upload and download files. Access to the learning environment was provided via the World Wide Web and saved by personal login data. The home page described the basic structure of the seminar with a timetable and news ticker. The navigation bar on the left side included general information about the seminar, and all specific topics relating to the content of the seminar. In addition, communication with the tutor was made possible via a question board.

Schedule and procedure
Every semester, this virtual seminar is offered to undergraduates. The data from this seminar was taken from the winter term 2002/2003. The seminar consisted of four phases:

- **Presentation and exploration:** During the first week, learners were invited to introduce themselves to the other participants in the seminar. Time was also taken to explain the learning environment, present the course schedule, and discuss the problems relating to collaborative learning in asynchronous scenarios. During this phase, learners should become acquainted with one another.

- **Clarification and coordination:** The first task for the three groups involved explaining the term “knowledge”. As this was the first task to be solved collaboratively, it was necessary to stress the overall coordination of the group for future collaboration. The members should start to feel like a group and act as a group.

- **Collaborative knowledge acquisition:** This phase was the core element of the seminar. Learners had to work collaboratively to solve four cases about knowledge management (see above). Learners were
given 12 days to complete each topic. Learners communicated via the learning environment in
discussion forums. Each group had access to its own forum (see figure 1). In this phase, learners should
acquire most of their knowledge about knowledge management.

- **Reflection and fading**: In the last phase, learners again worked systematically on the four topics of the
  seminar to summarize the relevant aspects and to integrate them into a complex overall picture. This
  phase was intended to stimulate deep learning processes and encourage participants to draw inferences
  between the individual topics and to construct a mental schema about knowledge management.

**Data collection**

Several different methods were developed for collecting data to evaluate the virtual seminar. First of all,
participants were asked to fill in questionnaires to evaluate aspects relevant to collaboration, namely pre-
knowledge, motivation, attitude towards group work, attitude towards virtual learning and computer experience.
Learners selected from a five-point Likert scale from “totally agree” to “disagree”. The Cronbach’s Alpha was
.61 for pre-knowledge, .65 for motivation, .58 for attitude to group work and virtual learning, and .65 for
computer experience. The questionnaire was developed according to Naumann and Richter (2001) and Stark
(1999).

In a second step, the **learning process** was analyzed with respect to epistemic activity, conceptual
space, dissemination of shared knowledge, and conflict-orientation. To achieve this, all written contributions
were rated according to a coding scheme. The contributions were then validated by a second evaluator who
assessed 20 per cent of all contributions. The inter-rater agreement was with $r > .96$ satisfying.

**Epistemic activities** included all the contributions which were related to the task and the task-solving
process. These were subdivided into content-specific and coordination-oriented epistemic activities. A
contribution was labeled as content-specific when it was connected to a theoretically based discussion. This
means that all statements which were related to the discussion of the content were rated as content-specific. All
statements which were necessary for temporal, structural and personal coordination were categorized as
coordination-oriented. These contributions were part of the planning and organization of the group work. All
kinds of social talk were considered to be non-epistemic. To analyze the number of epistemic activities, all
contributions were divided into propositions and relativized based on their number of words.

The amount of theoretical concepts which were relevant for the task solution was labeled as **conceptual
space**. These concepts were part of the theoretical knowledge which was provided by the learning environment
(e.g. texts on each specific topic). First, we counted all the different theoretical concepts of each individual task
and group. Secondly, we wanted to identify how many of these theoretical concepts were new ones and how
many were from previous tasks. To compare the three groups, we calculated this value in per cent.

**Dissemination of shared knowledge** was analyzed in two steps: All the theoretical concepts mentioned
in the individual contributions and in the group product were counted. The theoretical concepts were again
provided by the learning environment (e.g. texts on each specific topic). Afterwards, the ratio between these
two measures was used to analyze the group’s efficiency in disseminating and re-using knowledge for task
solutions.

All critical contributions or suggestions for improving the task solutions were rated as **conflict-
orientation**. These statements aim at showing disagreement with the task solving process or the task solution.
Here, only epistemic talk was coded, not social talk.

In a third step, the **collaborative knowledge outcome** was collected by analyzing the group product
according to conceptual and situative knowledge (De Jong, & Ferguson-Hessler, 1996). The conceptual
knowledge referred to the content-specific knowledge learners had acquired (knowledge acquisition). Each
individual and correct theoretical aspect received one point. Then all the points were summed up to one score.
The situative knowledge measured the quality of the problem solving task (knowledge application). Here experts rated the amount of problem-solving power the group product had.

Results

Treatment Check
Before we look at the results of our research questions, we wanted to know whether the three groups were comparable in various aspects relevant to collaboration. To do this, we looked at the group’s pre-knowledge, motivation, attitude to group work and virtual learning, and experience with computers (see table 1). As can be seen from the data, the three groups did not differ in these characteristics.

Table 1: Pre-requisites of the learners in the three groups from 1 to 5 (max. 5.00)

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-knowledge</td>
<td>2.50 (.79)</td>
<td>2.08 (.32)</td>
<td>2.13 (.61)</td>
</tr>
<tr>
<td>Motivation</td>
<td>4.75 (.50)</td>
<td>4.75 (.29)</td>
<td>4.50 (.50)</td>
</tr>
<tr>
<td>Attitude to group work</td>
<td>4.31 (.77)</td>
<td>4.25 (.65)</td>
<td>4.25 (.40)</td>
</tr>
<tr>
<td>Attitude to virtual learning</td>
<td>3.42 (1.07)</td>
<td>3.42 (1.23)</td>
<td>4.20 (.77)</td>
</tr>
<tr>
<td>Experience with computers</td>
<td>3.88 (.97)</td>
<td>4.13 (.72)</td>
<td>4.35 (.73)</td>
</tr>
</tbody>
</table>

Research Question 1

For analyzing group work, we investigated the individual contributions of every group according to relevant processes. We concentrated our analyses on epistemic activities, on the construction of a conceptual space, on the dissemination of shared knowledge and on conflict-orientation.

**Epistemic activities.** We divided epistemic activities into content-specific and coordination-oriented epistemic activities. All contributions which were not related to the case were considered non-epistemic activities. As we can see in table 2, non-epistemic activities were low in all cases and lowest in cases 2 and 3. They were highest in the first case solution. It is possible that participants exchanged social information in the beginning to get to know one another better. Furthermore, we can see in almost all groups (with the exception of group 3 in task 2) that content-specific epistemic activities were highest in cases 2 and 3, while coordination-oriented epistemic activities were lowest in these cases.

Table 2: Epistemic activities in per cent for each group in the 4 cases

<table>
<thead>
<tr>
<th></th>
<th>Content-specific</th>
<th>Coordination-oriented</th>
<th>Non epistem ic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Case 1</td>
<td>Case 2</td>
<td>Case 3</td>
</tr>
<tr>
<td>Group 1</td>
<td>48.62</td>
<td>68.84</td>
<td>55.83</td>
</tr>
<tr>
<td>Group 2</td>
<td>28.13</td>
<td>65.69</td>
<td>67.18</td>
</tr>
<tr>
<td>Group 3</td>
<td>47.26</td>
<td>39.87</td>
<td>52.84</td>
</tr>
</tbody>
</table>

Construction of a conceptual space. To more closely investigate the conceptual space, we first analyzed the number of new theoretical concepts for each of the four different cases. The three groups did not exhibit a general trend relating to mentioning new concepts in respect to time or case in either the conceptual knowledge task or in the situative knowledge task. We only can see that overall group 2 contributed more theoretical concepts than group 1 or group 3 (see table 3).

Table 3: Total numbers of new theoretical concepts as an indicator of conceptual space in the 4 cases for each group divided into conceptual (CK) and situative (SK) knowledge tasks

<table>
<thead>
<tr>
<th></th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>CK</td>
<td>SK</td>
<td>CK</td>
<td>SK</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>25</td>
<td>19</td>
<td>33</td>
</tr>
<tr>
<td>Group 2</td>
<td>CK</td>
<td>SK</td>
<td>CK</td>
<td>SK</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>21</td>
<td>46</td>
<td>42</td>
</tr>
<tr>
<td>Group 3</td>
<td>CK</td>
<td>SK</td>
<td>CK</td>
<td>SK</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>29</td>
<td>34</td>
<td>31</td>
</tr>
</tbody>
</table>

In a second step, we measured how many of the theoretical concepts mentioned were new (see table 4).
In tasks 1 and 2, learners mostly mentioned new theoretical concepts. Because the first case involved a new topic, it is evident that 100 per cent of the theoretical concepts mentioned in the first task were totally new. The least number of new concepts were used in case 3, whereas in the fourth case the number of new concepts increased again.

**Dissemination of shared knowledge.** It is necessary to analyze the dissemination of shared knowledge to evaluate how effective groups were in integrating their knowledge into their joint group product. As table 5 shows, the ratio between the theoretical concepts disseminated in individual contributions to those used in the group product was highest in group 1 and lowest in group 2. There was no general increase in efficiency over time, but groups 1 and 3 were least efficient in the first case.

**Conflict-orientation.** There was not an increase in conflict-orientation of the three groups during the virtual seminar as an indicator of the deep elaboration of knowledge. We can only see that group 2 differs from group 1 and 3 in the total amount of conflict-oriented statements (see table 6).

**Research Question 2**
In research question 2, we were interested in the quality of the group products. We analyzed conceptual and situative knowledge separately. When investigating conceptual knowledge, all groups exhibited almost the same level of quality in all four cases (see table 7). There was no increase in quality over time.

When investigating situative knowledge - the knowledge application task - the groups differed in their knowledge with respect to the cases (see table 7). All the groups performed better in cases 2 and 3 than in cases 1 and 4 for both conceptual and situative knowledge.
Table 7: Quality of group products in conceptual and situative knowledge (both maximum 10)

<table>
<thead>
<tr>
<th></th>
<th>Conceptual knowledge</th>
<th></th>
<th>Situative knowledge</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Case 1</td>
<td>Case 2</td>
<td>Case 3</td>
<td>Case 4</td>
</tr>
<tr>
<td>Group 1</td>
<td>5</td>
<td>8</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Group 2</td>
<td>4</td>
<td>6</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Group 3</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

Research Question 3
We identified some significant correlations between the learning processes and the group product (see table 8). Situative knowledge was positively related to content-specific epistemic activities and negatively related to coordination-oriented epistemic activities (Cohen, 1994). Furthermore, situative knowledge was also highly positively correlated to conceptual space and conflict-orientation.

Table 8 Correlations (Spearman-Rho) between learning processes and group product

<table>
<thead>
<tr>
<th></th>
<th>Conceptual knowledge</th>
<th>Situative knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epistemic activities: Content-specific</td>
<td>.02</td>
<td>.67**</td>
</tr>
<tr>
<td>Epistemic activities: Coordination-oriented</td>
<td>.34</td>
<td>-.53*</td>
</tr>
<tr>
<td>Conceptual space: total number of concepts</td>
<td>.09</td>
<td>.57*</td>
</tr>
<tr>
<td>Conceptual space: total number of new concepts</td>
<td>-.37</td>
<td>-.19</td>
</tr>
<tr>
<td>Knowledge dissemination</td>
<td>.38</td>
<td>-.23</td>
</tr>
<tr>
<td>Conflict-orientation</td>
<td>.01</td>
<td>.74**</td>
</tr>
</tbody>
</table>

Annotation. * = p < .05; ** = p < .01; n = 12.

Summary and discussion
In this field study, we investigated the learning processes and learning outcome of three groups of learners during a virtual seminar. To ensure the comparability of the three groups, we looked at differences in the learner’s pre-knowledge, motivation, attitude to group work and virtual learning, and experience with computers. We did not identify any differences between the three groups. As this is a case study in the field with a very small number of groups, the results are more a starting point for future investigation than generalizable on other virtual learning environments.

Firstly, we had a closer look at learning processes. To do this, we analyzed all of the contributions typed by the group members in a very detailed way. We could not identify a general time-related trend for the three groups with respect to the four categories of epistemic activities, creating a conceptual space, dissemination of shared knowledge and conflict-orientation. As a general rule, collaboration was influenced by the task itself and not by the learner’s potentially increasing collaboration and task-solving abilities. But when we look at the process analyses in more detail, there are some interesting findings. With respect to epistemic activities, all learners were highly involved in the task-solving activity, so that, with the exception of the first case, social or off-task talk was very low. This may be due to the fact that learners first wanted to get to know each other better before collaborating more intensively. Content-specific and coordination-oriented epistemic activities were mostly reciprocal: If the number of content-specific activities was high, the number of coordination-oriented activities was at least 20 per cent less than content-specific activities and vice versa. Especially in cases 2 and 3, content-specific activities were highest, while coordination-oriented activities were lowest. For case 2, this could be supported by the fact that the highest total number of new theoretical concepts were presented in this case for creating a conceptual space. When we have a further look at the group efficiency, we see that in the first case, all groups had difficulties in making the knowledge from the contributions useful for the group product. In the cases that followed, the ability to collaborate efficiently increased for groups 1 and 3, but not for group 2. Evidently groups 1 and 3 had better collaboration strategies than group 2, which did not perform as well. In general, we found a relatively low number of conflict-orientated utterances, which replicates the results of experimental studies in which learners engage in knowledge acquisition (Reiserer, 2003) or in knowledge application (Fischer, et al., 2002). Perhaps, learners are afraid of offending group members when expressing disagreement with their contributions or when criticizing them on a task-level.

In a second step, we investigated the four group products. Conceptual and situative knowledge increased or decreased depending on the case, but did not continually improve. Overall, group 1 performed best in the acquisition of conceptual knowledge and group 3 performed best in the acquisition of situative knowledge. The quality of the group product was best in cases 2 and 3. Evidently, when the groups are first formed, they do not work as effectively as in cases 2 and 3. The reason why learners did not perform as well in the last case may be due to their other duties as students. Clearly this would not be a factor for learners
participating in a laboratory experiment. At the end of the semester, the students had to take tests (Schnurer, 2005) which reduced their time and cognitive capacity for solving the cases in the seminar. It is also possible that learners were not as motivated to participate so intensively in the case-solving process at the end of the semester.

When investigating the correlations between learning processes and learning outcomes, only situative knowledge is significantly related to learning processes, not conceptual knowledge acquisition. We identified four main correlations. Epistemic activities were positively related to situative knowledge as long as they were content-specific. When learners engage more in content-specific aspects, their collaborative learning outcome in situative knowledge improves. But when they engage in coordination-oriented activities, the quality of the group product suffers. When learners engage in the subject matter, i.e. when they discuss and elaborate main aspects of a topic, their group product can profit from this deep cognitive involvement. Coordination is necessary for collaboration, but it does not improve the quality of the group product. This is due to the fact that coordination is not related to content elaboration, but to the way in which learners should proceed in solving their task. The total number of theoretical concepts mentioned in the contributions is deeply connected to situative knowledge acquisition. The group product improves when learners mention more adequate theoretical concepts in their contributions. This is the case, because when an increased number of concepts is disseminated, there is a greater opportunity for learners to integrate them into the group product. Furthermore, conflict-orientation is also related to situative knowledge. The quality of the learner’s solution improved in cases where learners spent more time critically discussing content-specific aspects. Socio-cognitive conflicts stimulated by disagreement can also improve problem-solving (Doise, & Mugny, 1984).

When we take a closer look at the three groups and compare them with one another, we can see that groups 1 and 3 differed from group 2 in some respects. When analyzing the learning processes between the groups, we see that group 2 was more engaged in content-specific activities and in the dissemination of theoretical concepts for cases 2 and 3 than groups 1 and 3. But when we have a closer look at group efficiency, group 2 was least efficient. Despite this fact, the quality of their group products was not worse than the group products of groups 1 and 3. Furthermore, group 2 made a lot of conflict-oriented utterances; however, these especially came about when working on tasks for conceptual knowledge, and not when working on tasks for situative knowledge. Only conflict-oriented utterances relating to situative knowledge are positively correlated with group performance. For this reason, we can conclude that the learning processes of group 2 were not as efficient as the ones of groups 1 and 3. In one respect, this group showed a lot of effort in their collaboration, but was not successful in their group products. This is because they were too conflict-oriented in knowledge acquisition tasks, but not in knowledge application tasks.

For sure, all these results are just a starting point for future research. In fact, even though we had a very small sample, we did quantitative analyses, no qualitative analyses to get a deeper insight into online collaboration. Future studies should include a bigger sample and qualitative data as additional material to deeper illustrate collaboration. Furthermore, different kinds of data analyses could be conducted with a bigger sample.

Conclusions
Overall, the analysis of the collaboration in virtual seminars showed very complex cognitive processes. Learning processes changed over time depending on the task. In fact, content-specific epistemic activities as well as the engagement in theoretical concepts and conflict-orientation are relevant for the learner’s success in collaboration. This is a very important finding, because to date, such results were only found in experimental conditions (Bruhn, 2000, Fischer et al., 2002, Reiserer, 2003). In addition, as we have seen in the group comparison, different learning activities influence the collaborative task-solving process. Further instructional support can especially focus on improving these learning activities. There are two main potential methods: conducting a training in collaboration before the virtual sessions (Rummel, & Spada, 2005) or using scripts, which could be directly implemented in the virtual learning environments (e.g. Weinberger, Ertl, Fischer, & Mandl, 2005). This investigation has provided further insights into virtual collaboration in real learning settings.

References


Weinberger, A. (2003). *Scripts for computer-supported collaborative learning.* Online: [http://edoc.ub.uni-muenchen.de/archive/00001120/01/Weinberger_Armin.pdf](http://edoc.ub.uni-muenchen.de/archive/00001120/01/Weinberger_Armin.pdf).
