Improving
Computer-Mediated Collaboration

Development and Empirical Evaluation of Two
Instructional Support Methods

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Introduction and Overview

This dissertation is part of the research project “Netzbasiertes kooperatives Lernen mit ausgearbeiteten Kooperationsbeispielen und Kooperationsskripts bei komplementärer Expertise” [Netbased Cooperative Learning on the Basis of Complementary Expertise: Providing Support with Worked-out Cooperation Examples and Cooperation Scripts] granted to Prof. Hans Spada and Prof. Franz Caspar by the DFG [German Science Foundation] within the Special Priority Program “Netzbasierte Wissenskommunikation in Gruppen” [Netbased Knowledge Communication in Groups], which was initiated by Prof. Friedrich Hesse (Tübingen), Prof. Ulrich Hoppe (Duisburg), and Prof. Heinz Mandl (München) in 2000.

The central goal of this research project is to develop potentially sustainable support measures for collaborative, interdisciplinary problem-solving in a computer-mediated setting.

The research within this project is based on the following scenario: Individuals with expertise in different content domains collaborate on solving a complex problem. The solution of the problem requires knowledge from all involved disciplines. As the experts cannot meet in person, they make use of a modern remote communication system to collaborate. A setting and task with practical relevance and realistic complexity were chosen: the interdisciplinary collaboration of medical doctors and psychologists on the treatment of psychiatric cases.

Upon this background the research project poses the question: How can such collaboration based on complementary domain knowledge be supported in a computer-mediated setting? Three goals for the conceptual and empirical work follow from this question: The first goal is to contribute to a theory of what constitutes a successful computer-mediated interdisciplinary collaboration. Second goal is the development of efficient instructional methods (model learning, script learning) to improve the relevant competences and strategies to achieve such collaboration. Due to the specific situational context that was chosen, the promotion of computer-mediated interdisciplinary collaboration on psychiatric cases and the design of a corresponding instructional unit is a third goal of this project.
These are the overarching goals of the project. Within the project, my dissertation work resides mainly within the second goal, the development and empirical testing of support measures with an instructional focus. A further emphasis of my work was on developing methods to analyze collaborative processes.

Computer-mediated collaboration among spatially distributed people is a precondition for success in many new learning and working contexts. However, the success of solving tasks and learning collaboratively in such settings is not easy to achieve. The challenge of working collaboratively is often aggravated by the distribution of information, resources, and expertise among the collaborating partners. Then, the remote computer-mediated scenario adds a new challenge because of the restricted possibilities for exchanging particular aspects of communication. It is characteristic of such settings that they require good communication and coordination in addition to individual problem-solving skills.

To meet the challenges encountered in computer-mediated collaboration settings, instructional approaches were developed to improve collaboration by promoting the collaborative skills and knowledge of the people involved in jointly working on a task. The rationale was that strategies necessary for good and effective computer-mediated collaboration may be conveyed to people by exposing them to adequate instructional measures. Two instructional measures were developed and investigated: (1) In a “model condition” people were provided with an elaborated worked-out example of a good collaboration. The model consisted of recorded model dialog and animated text, which allowed the observers to follow the development of the model solution on the shared text editor. (2) In a “script condition” the collaborating partners were provided with a script guiding them step by step through their collaboration on a first task.

The main hypothesis was that the instruction provided by the model and the script would promote people’s collaborative skills and increase their capability to collaborate in a fruitful way in subsequent collaboration. To test this hypothesis the experimental design consisted of two clearly separated phases: In the first phase (learning phase) the instructional treatments were implemented. The second phase (application phase) was the source for applying and testing the acquired skills. The partners collaborated freely on the second task. The quality of the collaborative
process, the joint work product, and the results of an individual posttest on knowledge about collaboration were analyzed.

As part of the data analysis various methods to analyze collaborative process were developed, including logfile analyses of activity patterns, analysis of video data and transcribed dialogs with a system of criteria, as well as qualitative content analyses. Criteria for the quality of the collaborative process included: (a) Aspects of the coordination of the collaboration: time management, division of labor and roles, and particularly the division of the collaboration process into individual and joint work phases. (b) Aspects of the communication: elicitation, explication, various types of providing mutual feedback, and also characteristics of turn-taking. These criteria were complemented by (c), Aspects concerning the solution of the task itself.

The computer-mediated scenario consisted of a desktop-videoconferencing environment including audio- and video-connection, personal text-editors and a shared text-editor. The collaborative task was the interdisciplinary solution of psychiatric cases with combined psychological and physical pathology. Dyads of advanced medical and psychology students were asked to jointly diagnose the patients described in the cases and to develop a suitable therapy plan making use of their complementary expertise.

In an experimental study the two instructional conditions (model and script) were compared with a third condition in which the partners collaborated freely (without instruction) during both phases, and a fourth (control) condition limited to the application phase. Both the model and the script condition showed positive effects on process and outcome of the second collaboration in the subsequent application phase.

The dissertation consists of four papers that represent different phases of the project and my dissertation work. A short overview of the papers is given below.

The first and main paper was submitted to the Journal of the Learning Sciences in December 2002. A revised version was re-submitted in July 2003. This is the version included here. The paper was accepted for publication with minor revisions on January 23 2004. The paper introduces the theoretical approach of the research project and the experimental paradigm of the empirical study. It gives an extensive overview of the main features of the empirical study (material, participants, condition, experimental procedure, dependent variables), and summarizes and discusses its central results.


The second paper complements the first by presenting some additional findings from the quantitative process analysis (analysis of the activity patterns). This paper was published in the proceedings of the International Conference on Computer Support for Collaborative Learning (CSCL) 2003, which was held in Bergen, Norway, in June 2003. The acceptance of papers to this conference was particularly competitive with a rejection rate of over 70%. The paper was nominated for the best student paper prize.


The third paper included in the dissertation is a book chapter to appear in the book “Barriers and Biases in Computer-Mediated Knowledge Communication and How They May Be Overcome”, edited by Prof. Bromme (Münster), Prof. Hesse
(Tübingen), and Prof. Spada (Freiburg). The book is the outcome of an international workshop with the same title that was organized in June 2002 and funded by the DFG. This paper begins with a detailed analysis of the setting that was at the heart of the present research project. The three features of the setting: (1) problem-solving and learning in collaboration, (2) on the basis of interdisciplinarity, and (3) computer-mediated, are discussed extensively. The chapter is also concerned with support measures and particularly methods to assess the effects of such measures and of collaborative process in general. The three levels of assessment, process, outcome and knowledge, are discussed in more detail than an empirical journal article would allow. The paper also includes a summary of the empirical study and its main results. Finally, the lessons learned both on the effects of our instructional support measures, as well as on the assessment methods implemented for analyzing the collaborative process, are discussed.


The fourth paper is the long version of a paper presented at the biennial conference of the European Association for Research on Learning and Instruction (EARLI) in Padua, Italy, in August 2003. The paper was presented as part of a symposium on “Communication and collaboration in computer-mediated settings: Difficulties and support” organized by Prof. Paul Kirschner from the Educational Technology Expertise Center at the Open University of the Netherlands and myself. Only the abstract of the paper was published in the conference proceedings; the long paper version was provided to participants upon request. This paper focuses particularly on the script condition of the empirical study. Different approaches to structuring interaction processes by providing cooperation scripts are introduced and illustrative examples given: (1) scripts that originate from traditional collaboration research and (2) scripts that have been developed to provide support for collaboration in computer-mediated collaboration. Secondly, recent attempts of Dillenbourg (2002) and Kollar, Fischer & Hesse (2003) to come up with classification systems to characterize scripts according to their constitutive features are described. Possible
drawbacks and pitfalls of cooperation scripts are discussed. The cooperation script that was used in our studies is introduced and classified with the two systems. Finally, the central question of the script condition realized in our work is discussed: whether people might be able to learn collaboration by following a script.

While the four articles each focus on different aspects of the research project and the empirical study, it should be noted that they naturally overlap to some degree as each paper has to introduce the main goals of the research project as well as the rationale and main features of the experiment.

In the following four sections, the papers are presented in the order described. Finally, the findings are critically evaluated in an overall discussion. The overall discussion section further includes a discussion of some theoretical aspects that are not included in the papers.

Appendix A shows the list provided participants together with the case description and their text materials. Appendix B presents the two cases utilized in the experimental study. Appendix C illustrates the experimental setting. Participants were seated in two different rooms only connected with the desktop videoconference. In a third room the experimenter could observe the process and, for example, intervene to provide help with the technology if necessary. Appendix D gives a summary of the dissertation work in German as required by the Promotionsordnung. Appendix E gives a list of further publications and conference presentations.
Learning to Collaborate:
An Instructional Approach to Promoting Collaborative Problem-Solving in Computer-Mediated Settings
Abstract

Effective collaboration in computer-mediated settings among spatially distributed people is a precondition for success in many new learning and working contexts, but hard to achieve. We have developed two instructional approaches to improve collaboration in such settings by promoting people's understanding of what characterizes good collaboration and, thereby, increasing their capabilities to collaborate in a fruitful way. The rationale is that strategies necessary for a good and effective computer-mediated collaboration may be conveyed to people by exposing them to an elaborated worked-out collaboration example (observational learning) or by giving them the opportunity to learn from scripted collaborative problem-solving. An experimental study was conducted comparing learning from observing a worked-out collaboration example with the learning effects of scripted collaborative problem-solving, the effects of unscripted collaborative problem-solving, and a control condition without a learning phase. The experimental design provided clearly separated phases for the instructional treatments (learning phase) and for applying and testing the acquired skills (application phase). Both observing a worked-out collaboration example and collaborating with a script during the learning phase, showed positive effects on process and outcome of the second collaboration in the application phase.

Keywords

Computer-mediated collaboration, cooperation script, observational learning, worked-out collaboration example
1 Introduction

The dynamically evolving technological solutions for computer-mediated communication have brought about new possibilities for collaboration among spatially distributed people. In working contexts such as remote surgery, web design or the assessment of cases in international law firms the use of technology for remote collaboration is on the uprise (Leskovac, 1998; Nardi, Kuchinsky, Whittaker, Leichner & Schwarz, 1997; Whittaker, 1995). In consequence, computer-mediated collaboration has moved into the focus of technological, organizational and – more recently – educational and psychological research (Koschmann, 1996; Koschmann, Hall & Miyake, 2002).

However, while computer-mediated collaboration makes available great opportunities for joint problem-solving across barriers of time and distance, the successful use of such settings can not be taken trivially. Difficulties arise concerning the coordination of the joint solution of the task at hand (i.e. with regard to work coordination such as managing time, division of labour and integrating individual contributions; Daly, 1993; Hiltz, Johnson & Turoff, 1986, Hermann, Rummel & Spada, 2001) as well as the communication (turn taking, giving feedback, mutual understanding; McKinlay, Procter, Masting, Woodburn, & Arnott, 1994; O’Conaill & Whittaker, 1997). Without adequate support, collaborating partners often fail to complete their joint task or find that it requires too much time and effort (Anderson et al., 1997; Galegher, Kraut & Egido, 1990; Olson et al., 1993; Straus & McGrath, 1994).

The development of effective support measures depends upon answers to the questions: What constitutes good collaboration in computer-mediated settings? And next, how can such collaboration be achieved? We argue that an instructional support approach could provide a particularly powerful way of improving collaboration. It is our assumption that we can promote people’s capabilities for good collaboration by helping them to acquire a deep understanding of the important characteristics of a good collaboration through new forms of instruction.

To test the effectiveness of these instructional measures, an experimental study was conducted. Learning effects resulting from observing a worked-out collaboration
example were compared to those of scripted collaborative problem-solving, the learning effects of unscripted collaborative problem-solving and a control condition without a learning phase.

2 Remote Collaboration

2.1 A Scenario

Picture the following scenario: a medical doctor and a psychologist are asked to collaborate on solving a complicated clinical case. As the case involves both a physical illness (multiple sclerosis) and psychopathological symptoms, the assessment requires the two individuals to make use of their complementary expertise. Their joint task is to formulate a report that includes a detailed diagnosis for the patient and a proposal of a suitable therapy. The two experts are not able to meet in person as they work at distant locations and cannot afford the time to meet. Instead, they have decided to take advantage of a desktop videoconferencing system that has recently been implemented at both of their institutions.

What are the generic features of the scenario, making it worthwhile to analyze this type of task and search for ways to improve the collaboration by instructional means? One designative feature is the challenge to solve a complex task collaboratively on the basis of complementary domain knowledge of the collaborating partners. This feature merges with the challenge of communication and collaboration in a computer-mediated setting. In the following, we will discuss these challenges in more detail. We will describe the technical setting, define what is meant by “collaboration” and outline why support is necessary. Finally, we describe the characteristics of a good collaboration in this and similar working contexts.

2.2 Characteristics of Desktop Videoconferences

Desktop videoconferencing systems constitute one particular instance of remote computer-mediated collaboration (Finn, 1997). In a desktop videoconference, participants in different locations each sit at their individual computer and communicate with one another via an audio-video connection. On the computer screen they can see video pictures of the remote partners. Each video picture is
captured by a small camera sitting on top of the computer screen or placed directly to the side of the screen. There is also an audio channel. In addition, these systems often include shared applications (e.g. Word documents, Excel spreadsheets or visualization tools; Whittaker, Geelhoed & Robinson, 1993). The shared applications offer the possibility for joint manipulation of objects, data or documents in a workspace that is visible and accessible for all participants simultaneously (Dillenbourg & Traum, 1999; Gürer, Kozma & Millán, 1999; Whittaker et al., 1993).

2.3 The Collaborative Task

How can we characterize the collaboration required in the given type of scenario? Following the discussion by Dillenbourg (1999, p. 9 ff) three dimensions characterize a collaborative situation. The first dimension is symmetry, which he further divides into symmetry of actions (“the extent to which the same range of actions is allowed to each agent”, p.9), symmetry of knowledge (“the extent to which the agents possess the same level of knowledge “, p.9), and symmetry of status. In the current scenario, the desktop-videoconference setting sets the stage for symmetry of action. Both partners can equally hear and talk to each other; both have equal access to a shared text editor as well as to individual text editors. Symmetry of knowledge and status is also given as the two partners each are expert in their respective domain. As we have described above, the collaboration in the present scenario rests on the “complementary expertise” of the partners. Interdisciplinary collaboration given a situation of “complementary expertise” can be characterized as follows: the partners of the collaboration complement one another in that each of them possesses a relevant part of the unshared knowledge. Each of the partners is a “novice” in the other’s domain and an “expert” in his own. In other words: while they do possess different knowledge, the level of their “knowledgeability” is symmetric.

The second dimension of a collaborative situation that Dillenbourg (1999, p. 10) describes is that the partners have common goals – as opposed to conflicting goals that would characterize a competitive situation. Common overarching goals do, however, not preclude diverging opinions at the subgoal-level. The repeated negotiation of shared goals over the course of a collaboration is part of constructing and maintaining common ground. In the present scenario the overarching common goal is to come to a diagnosis and develop a therapy plan for the patient under
scrutiny. However, the subgoals of how to get there have to be set and negotiated by the partners.

The third constitutive dimension of a collaborative situation according to Dillenbourg (1999, p. 11) is the division of labor among the partners. This dimension has sometimes been used to distinguish between “cooperation” and “collaboration”. Cooperation has been described to include a division of labor, the parallel independent solution of sub-tasks and the combination of individual contributions in a joint product. Collaboration, on the other hand, has been defined as doing the work together. Following this distinction makes it hard to decide where to place our type of scenario. On the one hand it is cooperative in the way that both partners will contribute to the joint solution in different ways due to their complementary expertise. At some points a division of labor and individual work on subtasks will be inevitable. On the other hand one could also define the task as collaborative since the partners will maintain an immediate interactive contact over the videoconference for the entire time. Without collaboration, a joint solution integrating both the medical and the psychological perspective would be impossible. In fact, Dillenbourg argues that the distinction of cooperation and collaboration according to the criterion of division of labor is somewhat arbitrary. In accordance with his arguments we use the terms cooperation and collaboration synonymously.

2.4 Constraints and Challenges: Why Support is Necessary

Extensive research has shown that the success of collaborative efforts does not occur by itself (Diehl & Stroebe, 1991; Johnson & Johnson, 1992; McGrath, 1984; Slavin, 1995; Salomon & Globerson, 1989). Without systematic support people differ greatly in the way they collaborate, depending on a variety of interacting conditions like group size, group composition, collaborative task or the media used for communication (Dillenbourg, Baker, Blaye & O’Malley, 1995). Some groups collaborate quite efficiently and with good success even when let on their own. However, the majority of collaborations only succeed with adequate support.

In addition to this very general argument, two more particular aspects of the present scenario call for supporting the collaborating partners:

Collaboration is particularly difficult in the case of “complementary expertise” of the collaborating partners, as in the scenario outlined above. On the one hand,
complementary expertise can provide a prolific and promising basis for collaborative problem-solving. Such collaboration is considered to be the key to a successful exploration of complex phenomena, where taking into account only one perspective would fall short (Gibbons et al., 1994; Ploetzner, Fehse, Kneser & Spada, 1999). However, at the same time, interdisciplinary collaboration is not an easy undertaking (Lewis & Sycara; 1993; Bromme 2000). Problems known to be symptomatic for collaborative learning and problem-solving in general, for example, instantiating and sustaining “convergence” (Roschelle & Teasley, 1995), coordinating the collaboration (Barron, 2000; Malone & Crowston, 1990), and pooling unshared knowledge (Stasser & Titus, 1985), apply to an even greater extent to interdisciplinary collaboration (Thompson Klein & Porter, 1990; Stasser, Stewart & Wittenbaum, 1995). A well-balanced proportion of individual and joint work phases is of central importance for the quality of the problem-solving process (Hermann et al., 2001). Allowing enough time for individual work is crucial to ensure that the partners can bring their individual domain knowledge to bear.

The second aspects concerns the nature of the computer-mediated setting. Depending on the quality of the audio and video transmission, videoconferencing systems appear to offer almost face-to-face conditions for collaboration. However, research in video-mediated communication has shown that communicational behavior in video-conference settings is different to that in face-to-face settings (Anderson et al., 1997; O’Conaill & Whittaker, 1997). Even with a very good technical quality, the expenditure of any form of collaborative activity in videoconferences is increased by an additional and more explicit effort (Anderson et al., 1997) concerning, for example, the processes of grounding (Clark & Brennan, 1991), turn-taking, or giving feedback. Furthermore, the exchange of nonverbal and paraverbal clues is impeded, and eye contact is impossible. O’Conaill and Whittaker (1997) concluded that in video-mediated collaboration, explicit coordination of the communicative process requires extra effort.

So far we have argued that the present collaboration scenario exerts high demands on the collaborating partners, given the collaborative problem-solving task, the complementary expertise necessary for solving the task, and the challenges of remote collaboration. As a consequence, the collaboration, and specifically its coordination, need to be supported to ensure well-coordinated, efficient work. Before
we discuss possible ways of providing such support it is, however, necessary to define what a desirable collaboration in the given scenario might look like.

3 Characteristics of a Good Collaboration

All approaches to facilitate successful collaboration are in need of sound evidence on what aspects characterize a good collaboration. Such information is important for designing support measures and for evaluating their effects. However, up to now research on computer-mediated communication and collaboration seems to be lacking in theory. A comprehensive theory is missing. In our attempt to define relevant characteristics of a good collaboration we have therefore integrated empirical findings from different strands of research:

On a “macro” level, the coordination of the joint work is of great importance (managing time, dividing labor, pooling unshared knowledge, balancing individual and joint work phases, integrating individual contributions; Hermann et al., 2001; Johnson & Johnson, 1992; Malone & Crowston, 1990).

On a “micro” level, crucial aspects of a good collaboration concern the communication (turn taking, feedback, mutual understanding; O’Conaill & Whittaker, 1997).

With regard to the type of task at hand domain specific requirements of a good joint solution can be identified (Caspar, 1997).

In the following, these three levels of good collaboration will be described in more detail and specified for the scenario at hand.

3.1 Macro Level: Coordination

To ensure efficient work in the present scenario, it is crucial to coordinate the collaborative process in an appropriate way (Barron, 2000; Olson, Malone & Smith, 2001; Malone & Crowston, 1990). Hereby, coordination has to serve several goals: to specify the objectives of the work and reach a shared task alignment, to arrange the division of tasks between the partners, to manage their temporal synchronization and establish a chronological order of activities.
Further, a central goal of the coordination is to ensure the consistency of the joint work product, which means to integrate partial solutions of the partners. Particularly in the case of complementary expertise of the partners – as in the scenario at hand – the question of joint and individual working phases has to be considered (Hermann et al., 2001). What has to be prepared individually by applying disciplinary knowledge before integrating it into the joint solution? What elements of the preliminary joint solution are in need of a disciplinary reflection and revision? A well-balanced proportion of individual and joint work phases is crucial for a successful collaboration. On the one hand, allowing enough time for individual work is of great importance to ensure that the partners can bring their individual domain knowledge to bear. On the other hand, joint work phases with fruitful discussion of individual opinions are indispensable to ensure the exchange of unshared information.

### 3.2 Micro Level: Communication on the Basis of Complementary Expertise

At the “micro” level of the communication, the following aspects can be identified to be important for a good collaboration:

The way two people regulate turn-taking during their interaction is a determining factor for the quality of the collaboration. How do the partners determine who will speak when, how do they regulate transitions, how explicit (verbal) or implicit (nonverbal) are the turn-taking cues they give each another, these are some of the questions in the scope of turn-taking (Sacks, Schegloff & Jefferson, 1974). The smoother transitions among speakers are, the less the communication is interrupted by talking simultaneously. Especially in computer-mediated communication settings explicitly handing over a turn can be a good solution to compensate for the reduced possibilities to transmit nonverbal information.

Instantiating and sustaining mutual understanding is a constant challenge during the collaboration, a phenomenon widely known as “grounding” in communication (Clark & Brennan, 1991; Baker, Hansen, Joinier & Traum, 1999). When collaborating partners come from different disciplinary backgrounds, the establishment of a common ground and convergence (Roschelle, 1992) on central concepts is particularly important, yet also particularly difficult. In order to avoid
misunderstandings it is indispensable to use the partner as a source for clarifications and ask appropriate (comprehensible and relevant) questions.

Asking questions is further of central importance to foster the exchange of unshared information. The pooling of unshared information (accessible only to individual members of the group) is one of the crucial aspects of successful collaborative problem-solving and decision-making (Stasser & Titus, 1985; Larson, Christensen, Franz & Abbott, 1998). The failure of collaborating partners to pool their unshared knowledge resources is devastating in a situation where the group members mutually depend on each other’s knowledge to successfully complete the group task (Johnson & Johnson, 1992). Such a situation arises in the present scenario through the distribution of complementary expertise in the dyad.

Asking appropriate questions and giving answers at a corresponding level of complexity is, however, not trivial (King, 1994; Ploetzner, Dillenbourg, Preier & Traum, 1999; Renkl, 1997). Research on “audience-design” in expert-layperson communication (Clark & Murphy, 1982; Jucks, Bromme & Runde, 2003) has revealed that experts tend to underestimate the complexity of the subject and of their explanations. In particular, the pitfalls of an “illusion of evidence” (Jucks et al., 2003) have to be avoided when tailoring one’s explanations to the knowledge of the partner. The importance of adjusting the level of questions (information asked for) and answers (information provided) is further supported by results summarized by Webb (1989). Only explanations at an appropriate level of elaboration can be of any help to the questioner.

### 3.3 Domain Specific Demands

In solving psychiatric cases with combined psychological and physical pathology specific successful “expert” procedures should be considered (Caspar, 1997).

First of all, the diagnosis and planning of an adequate therapy need to be sequenced. Further, within each of the two components certain procedures have to be followed. It is important to justify the diagnosis from the case description, by describing how it relates to the symptoms listed. For the therapy plan it is important to carefully consider the goals of the therapy before planning concrete measures and methods. In addition, potential difficulties that can affect the success of the therapy need to be discussed. It is once again crucial to take into account the complementary
expertise within the dyad. A psychologist might interpret a symptom like constant fatigue as an indicator for a diagnosis of depression, while a medical doctor might recognize it as a side effect of some pharmacological treatment. In sum, on the one hand it is important that both partners can bring their relevant disciplinary knowledge to bear, and on the other, the consistency of the joint work product needs to be ensured.

3.4 Exemplary Collaboration

On the basis of the above considerations an exemplary collaboration pattern was developed which takes into account processes relevant for a successful collaboration on the task at hand. The exemplary collaboration allowed to determine elements of good collaboration to be facilitated by instructional measures.

This exemplary collaboration can be sketched as follows:

Overall, a successful collaborative problem-solving process for the task at hand (solution of psychiatric cases) requires roughly three parts. They include aspects of good collaboration from all three levels (macro, micro and domain specific):

In an initial phase, the partners coordinate their collaboration both temporally and with regard to content. First, they define the objectives of their task. Then, they take some time to look at the case description once more and formulate questions. Next, they collect information, mutually ask and try to answer questions about both, the case as well as the joint task – thereby taking advantage of their complementary expertise and using their partner as a resource for clarification. In this phase they also determine the joint course of action. This phase is crucial for an instantiation of mutual understanding, conceptual convergence and shared task alignment.

The main part of the collaboration consists of two sub-tasks: the development of a joint solution on the diagnosis and the therapy plan. During both sub-tasks a four-step pattern should be followed. To start with, an individual work phase should occur, enabling both partners to bring their disciplinary knowledge to bear. Following this, the individual ideas should be discussed, ensuring the exchange of unshared information. During the discussion, reciprocal understanding needs to be monitored. Following the discussion, the individual proposals have to be revised. The partial solutions are then integrated into the joint solution text, and a draft of the joint work product results.
A final phase of the collaboration has the goal of ensuring the consistency of the joint work product. The partners revise the joint solution and make final changes.

Figure 1 represents the activity pattern of this exemplary collaboration. The pattern can be divided into 12 phases, which relate to the three parts of the exemplary collaboration described above.

**Figure 1. Exemplary collaboration**

<table>
<thead>
<tr>
<th>Initial phase</th>
<th>Main phase</th>
<th>Final phase</th>
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<tbody>
<tr>
<td>1.</td>
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<td>2.</td>
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<td>3.</td>
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<td>4.</td>
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<td>5.</td>
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<td>6.</td>
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<td>7.</td>
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<td>8.</td>
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<td>9.</td>
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<tr>
<td>10.</td>
<td>10.</td>
<td>10.</td>
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<tr>
<td>11.</td>
<td>11.</td>
<td>11.</td>
</tr>
</tbody>
</table>

= 57 min.  = 63 min.

While the diagram does not depict the “micro” aspects of collaboration on the communicative level, it does show very well the pattern of activities on the macro level. For example, one can clearly see the alternation of individual and joint work phases during the collaboration. As stated above, especially in the case of a complementary knowledge background of the collaborating partners, a well-balanced proportion of phases of joint and individual work is crucial for the success of the collaboration. Individual and joint work should take up about half of the time each.

After having described relevant aspects of a good collaboration, the next step is to search for ways to achieve such interactions.
4 Instructional Approaches to Promote Computer-Mediated Collaboration

What do we mean by support? We introduce measures that aim at facilitating fruitful interaction. So far, most efforts to support computer-mediated collaborative problem-solving and learning have concentrated on direct, online support strategies, for example by shaping certain aspects of the collaborative situation (e.g. the interface), or by structuring the interaction by means of a cooperation script (for an overview see O’Donnell, 1999). However, these support strategies have been short-term interventions mostly directed towards achieving immediate effects on the outcome of a single collaboration. By contrast, we think that an instructional approach could provide a sustainable way of improving collaboration and its outcome by promoting people’s understanding of what characterizes good collaboration and, thereby, increasing their capabilities to collaborate in a fruitful way. But which instructional strategy is adequate to convey the relevant aspects of good collaboration to people and thereby promote their collaborative skills for subsequent interactions?

We regard it as promising to follow a situated learning perspective (Collins, Brown & Newman, 1989; Greeno and MMAP, 1998; Lave & Wenger, 1991) and introduce collaborators to the “craft of collaborating” by immersing them in a corresponding learning environment, in other words by involving them in “guided” collaborative activities. The idea of a situated approach is that the learning situation should resemble the application situation as closely as possible.

But how may people be guided to learn to collaborate?

4.1 Observational Learning from Worked-out Examples of Collaborative Problem-Solving

A promising instructional strategy would be to have people observe the model of a successful computer-mediated collaborative solution of a problem. We call such a model a “worked-out collaboration example”. While observing, people should reflect on the solution steps of the worked-out example and on the behavior of the collaborating partners. Elaborating on what they see in the model, should foster deep understanding, and help people learn what aspects they need to pay attention to during their own collaboration.
Why do we expect a worked-out collaboration example to be an adequate instructional means to help people gain insight into what good collaboration is and become better at collaborating themselves? And how should such a model be designed in order to offer optimal opportunities for learning?

Reimann (1997), Renkl (1997), VanLehn (1996) and others have emphasized that individual learning from worked-out examples can be a successful way of acquiring cognitive skills. Worked-out examples in physics or mathematics consist of a formulation of the problem, a description of the solution steps and the solution itself. This type of learning is primarily based on the self-explanation of the solution steps (Chi, Bassok, Lewis, Reimann & Glaser; 1989). Sweller and Cooper (1985) have provided evidence, that learning from worked-out examples is often more effective compared to learning by problem solving due to cognitive overload caused by the demands of the situation of unguided problem-solving. In sum, the strengths of worked-out examples are to reduce cognitive load, to focus learners’ attention on relevant aspects of the problem-solving process, and to foster the acquisition of adequate problem-solving schemas (VanLehn, 1996). Superficial processing and an illusion of understanding may be counteracted by promoting the elaboration and reflection of the example, especially by eliciting self-explanations (Renkl, Stark, Gruber & Mandl, 1998). Self-explanation activities can be promoted by various instructional measures, e.g. the provision of supportive instructional explanations (Renkl, 2002).

How do these results on individual learning with worked-out examples transfer to our scenario?

First and foremost our assumptions are supported by a small strand of research, which has shown that observational learning can be of special value in the context of dialog and discourse. Stenning and colleagues (1999) have provided empirical evidence that the observation of dialogs supports the acquisition of dialog competence. Along the same lines, a study by Cox, McKendree, Tobin, Lee and Mayes (1999) analyzed the effect of reading the content of a tutor-student dialog with positive results on subsequent dialog.

Furthermore, in industrial settings, a behavior modeling approach (Goldstein & Sorcher, 1974) based on observational learning (Bandura, 1977) has been shown to be an effective training method for the acquisition of complex behavioral skills.
(Latham & Saari, 1979, Meyer & Raich, 1983). Analogous to the role of elaboration support in processing worked-out examples, Decker (1984) has shown the importance of “learning points” – instructional explanations accompanying the model's behavior to support deep processing – in behavior modeling training.

Combining these different strands of research, we expect that observing the worked-out example of a well-structured computer-mediated collaboration and reflecting on the solution steps and on the behavior of the collaborating partners, constitutes a promising method to learn relevant aspects of what constitutes a good collaboration and to acquire collaborative skills with long term effects.

### 4.2 Learning from Scripted Collaborative Problem-Solving

A second instructional approach relates to a well-researched measure to support collaboration: cooperation scripts. The main idea behind the usual application of cooperation scripts is to enforce a fruitfully structured interaction by giving precise instructions on how to interact and thus reduce the costs of coordination. There is sufficient evidence to suggest cooperation scripts as effective measures for supporting face-to-face collaboration (O'Donnell & Dansereau, 1992; for an overview see O'Donnell, 1999), as well as collaboration in computer-mediated settings (Hron, Hesse, Reinhard & Picard, 1997; Reiserer, Ertl & Mandl, 2002). Hron and colleagues (1997) found that structuring the cooperation by employing a cooperation script, resulted in more effective dialog as well as an improvement in the joint problem-solving and knowledge acquisition in a text-based, synchronous computer-mediated collaboration setting.. The results presented by Reiserer et al. (2002) have extended the successful application of cooperation scripts to supporting collaboration in desktop-videoconferencing settings.

Yet, cooperation scripts have mostly been implemented as short-term “online” interventions directed towards immediate effects on the outcome of a single collaboration. But what are the long-term effects of cooperation scripts? Would it be possible to script collaboration over many sessions? Following the motivation theory of Deci and Ryan (1985), which identifies self-determination as a major constituent of motivation, cooperation scripts may cause motivational problems, since they often regulate the interaction in a too strict manner. Negative motivational responses of
participants are to be expected, particularly in the long term and with adult collaborators (Hron et al., 1997; Bruhn, 2000).

Another critical point may be that being guided by a script does not encourage reflection on the “whys” of the scripting. Without developing an understanding for the importance of the specific steps for a good collaboration, however, less deep learning may occur with regard to the desired collaborative skills. Moreover, not understanding the “whys” of the phases the script prescribes may further the negative motivational responses to the script.

From an instructional point of view the central question is, whether the effects of cooperation scripts extend beyond the experimental session in which they were provided, by promoting understanding of collaboration and the capabilities to collaborate. In short: Can people learn to collaborate by following a script?

4.3 Learning by Doing: Collaborative Problem-Solving Without Instructional Guidance

Another possibility would be just to involve people in collaborating on a task similar to the ones they will be confronted with later. In the present scenario, collaborating partners might thereby gain experience on at least three different levels: experience in performing the steps necessary to solve tasks of this type (problem-solving); experience in jointly working with the specific partner (collaborative problem-solving); and experience in communicating and working with the desktop-videoconference system (computer-mediated collaborative problem-solving). Such collaborative problem-solving without any additional help can be regarded as the most natural but also most restricted form of situated learning. The question is, whether relevant learning processes would actually occur in such a situation. Would people pay attention to the critical collaborative processes? Would they reflect upon their interactions and draw appropriate conclusion from these considerations? On the one hand, research on learning by solving problems (DeCorte, 1996; Evensen & Hmelo, 2000) as well as considerations on the potential of learning by doing (Schank, Berman & Macpherson, 1999) hold that this might be possible. On the other hand, however, cognitive load theory (Sweller & Cooper, 1985; Sweller, VanMerriënboer, Paas, 1998) strongly suggests that the demands of problem-solving in such a complex situation might cause cognitive overload and lead to failure of
both the problem-solving and the learning process. It can be expected that the present situation will be particularly likely to cause such overload, since the demands of solving the problem at hand are aggravated by the difficulties of working collaboratively, and in an interdisciplinary constellation, and by the challenges of computer-mediated interaction.

### 4.4 Learning from a Collaboration Example, a Cooperation Script, and from Unscripted Collaboration: Hypotheses

The central idea of our instructional approach is illustrated in Figure 2.

**Figure 2. Instructional hypotheses and data**

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Tested by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructional measures:</td>
<td></td>
</tr>
<tr>
<td>1) observational learning</td>
<td>Data on process (micro, macro, domain-specific level)</td>
</tr>
<tr>
<td>2) script learning</td>
<td></td>
</tr>
<tr>
<td><em>promote</em></td>
<td></td>
</tr>
<tr>
<td>Better understanding of important aspects of good collaboration</td>
<td></td>
</tr>
<tr>
<td>and improved collaborative skills</td>
<td></td>
</tr>
<tr>
<td>(micro, macro, domain-specific level)</td>
<td></td>
</tr>
<tr>
<td><em>make possible</em></td>
<td></td>
</tr>
<tr>
<td>Better computer-mediated collaborative problem-solving process on these levels</td>
<td></td>
</tr>
<tr>
<td><em>yields</em></td>
<td></td>
</tr>
<tr>
<td>Better joint solution</td>
<td>Data on outcome (diagnosis and therapy plan)</td>
</tr>
<tr>
<td>(diagnosis and therapy plan)</td>
<td></td>
</tr>
<tr>
<td>Better knowledge about relevant aspects of good collaboration</td>
<td>Data on knowledge (micro, macro, domain-specific level)</td>
</tr>
</tbody>
</table>

Participants in the conditions with instructional guidance (model and script condition) should acquire skills on all three levels (micro, macro, domain specific) during the learning phase. These skills should result in better collaborative problem-solving processes and thereby yield better joint solutions. An improved explicit knowledge about meta-aspects of collaboration and about the solution of the task should be a further consequence.
Main Hypothesis

We expect to find the following results with regard to performance in a second collaboration following the instructional phase: learning from observing a worked-out collaboration example and learning from scripted collaboration both will show better results than learning from unscripted collaboration and a condition with no opportunity for learning at all. As slight advantage is expected for learning from observing a worked-out collaboration example.

This main hypothesis is based on the following assumptions for the individual conditions:

Assumption 1

Providing a worked-out example of well-structured collaborative problem-solving promotes the acquisition of collaborative problem-solving skills. This type of observational learning from a collaboration example should be even more advantageous if elaboration activities are supported by instructional means – for example, explicit stimulation of self-explanatory activities and instructional prompts to direct the observer’s attention to relevant aspects of the collaboration example.

Assumption 2

Scripted collaborative problem-solving during a learning phase (= learning from a cooperation script) is expected to lead to collaborative problem-solving skills, which become manifest in the process and outcome of subsequent collaborative work. It must be taken into account, however, that negative motivational responses to the script could lead to learning problems and that being guided through the collaboration by a script does not further reflection on the various phases. Thus a slight disadvantage of the script condition as compared to the model condition would be expected.

Assumption 3

Unscripted collaborative problem-solving is not expected to be a very successful measure for promoting collaborative problem-solving skills, since the combination of a new, complex problem, collaboration, and interaction in a new computer-mediated setting is expected to cause cognitive overload.
Experimental Statement

To test the effects of the instructional approaches, the experimental design should provide clearly separated phases for learning and for applying the acquired knowledge.

5 Method

To test the effectiveness of our instructional approach to promoting relevant skills for a successful collaboration, an experiment was conducted comparing the three conditions outlined above and a control condition (see Table 1): (1) observational learning from a worked-out example of computer-mediated collaboration (model condition), (2) learning from scripted computer-mediated collaborative problem-solving (script condition), (3) learning from unscripted computer-mediated collaborative problem-solving (unscripted condition), and (4) control condition without a learning phase.

<table>
<thead>
<tr>
<th></th>
<th>Model condition</th>
<th>Script condition</th>
<th>Unscripted condition</th>
<th>Control condition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimental</strong></td>
<td>Observational learning from a worked-out example of computer-mediated collaboration</td>
<td>Learning from scripted computer-mediated collaborative problem-solving</td>
<td>Learning from unscripted computer-mediated collaborative problem-solving</td>
<td>No learning phase</td>
</tr>
<tr>
<td><strong>learning</strong></td>
<td>(case 1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>phase</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Application</strong></td>
<td>In all four conditions:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>phase</strong></td>
<td>Computer-mediated collaborative problem-solving</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>(case 2)</strong></td>
<td>(Dependent variables: collaborative process, outcome and posttest)</td>
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<td></td>
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</tbody>
</table>

The experimental paradigm set up comprised two phases: a learning phase and a subsequent application phase. During the learning phase, the experimental variation was implemented. The goal of the learning phase was the acquisition of knowledge about elements relevant for a good and potentially successful collaboration. Effects of the experimental variation were then expected to become evident in the application phase, which was the same in all conditions. Aspects of the collaborative problem-solving process during the application phase as well as its outcome – the joint solution – were investigated as dependent variables. Further, explicit knowledge
about elements of a good and potentially successful collaboration was assessed in a
posttest.

Table 2 shows the interplay of elements of good collaborative problem-solving, their
implementation by instructional measures, and their assessment. The table gives
an overview of all three levels, the “macro” level of coordinating the collaborative
process, the “micro” level of the communication, and the level of domain specific
demands of the joint work on the task. The previously identified aspects of good
collaboration were implemented in the instructional material of both worked-out
collaboration example and script. While the scenes of the worked-out collaboration
example modeled the aspects of good collaboration targeted by the instruction, the
script gave participants a step by step instruction to act correspondingly. The table
further shows how the assessment on all three levels. Details on the instruction
provided in the experimental conditions and on the analyses will be provided below.

Table 2. Sketch of the elements of good collaborative problem-solving, their implementation by
instructional measures and their assessment

<table>
<thead>
<tr>
<th>Theory elements</th>
<th>Implementation</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Macro level:</strong></td>
<td>Promotion of coordinative</td>
<td>Log-files of activity patterns, Dialogs: Analysis of coordinative categories, Postest scale A</td>
</tr>
<tr>
<td>coordination</td>
<td>skills</td>
<td></td>
</tr>
<tr>
<td><strong>Micro level:</strong></td>
<td>Promotion of communicative</td>
<td>Dialogs: Analysis of communicative categories (1), Postest scale A</td>
</tr>
<tr>
<td>communication</td>
<td>skills</td>
<td></td>
</tr>
<tr>
<td>and specifically</td>
<td></td>
<td></td>
</tr>
<tr>
<td>interdisciplinary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Domain specific</strong></td>
<td>Promotion of domain specific</td>
<td>Dialogs: Analysis of content related categories (1), Quality of the joint solution, Postest scale B</td>
</tr>
<tr>
<td>problem solution</td>
<td>skills</td>
<td></td>
</tr>
</tbody>
</table>

(1) Only assessed for 8 of the 36 dyads and not part of this paper.
5.1 Collaborative Task

In accordance with the scenario described at the outset, the collaborative task comprised the interdisciplinary solution of psychiatric cases with combined psychological and physical pathology. Dyads of advanced medical and psychology students were asked to jointly diagnose the patients described in the cases and to develop a suitable therapy plan making use of their complementary expertise.

5.1.1 Task Material

Two cases were utilized in the experiment. They were constructed by researchers in the field of clinical psychology in collaboration with psychotherapists and psychiatrists and were designed specifically to meet the requirements of this study. In both cases a psychological disorder coincided with some physical illness:

- Case 1: panic disorder and cardiac disrhythmia
- Case 2: depression and multiple sclerosis

In order to make the correct diagnosis and map out an adequate therapy plan, medical as well as psychological aspects had to be considered. Thus both cases made it necessary to take advantage of the complementary domain knowledge represented in each dyad. The pooling of unshared domain knowledge was indispensable to success in solving the collaborative task, as it was beyond the competence of each student individually.

Both case descriptions included information about current physical and psychological symptoms, the present living situation as well as details on the personal and medical history. Current medical treatments (e.g. medication) were indicated. It should be emphasized that the contents of the two cases were completely independent from each other. With regard to content knowledge no transfer was possible from case 1 to case 2.

In addition to the case description, participants were provided with instructional texts about task-specific psychological and medical aspects of diagnosis and treatment. Medical students received different text materials than students of psychology. For example, while medical students were given information on psychopharmacological treatments, psychology students received texts about
psychotherapeutic treatments. This distribution of relevant information served to increase the complementarity of domain knowledge.

## 5.2 Participants

36 advanced students of psychology and 36 advanced students of medical science volunteered to participate in the study. The students were paid for their participation. 36 dyads, each comprising a medical student and a student of psychology, were set up and assigned to one of the four conditions, resulting in a total of 9 dyads in each condition.

Prior to the actual study, a questionnaire was sent to students that had indicated their interest in participating, asking for information about: (1) domain knowledge, (2) technical skills, and (3) experience with working collaboratively.

1. The level of the students’ prior domain knowledge was assessed by asking for the courses they had attended. Since the contents of the courses are known, this allowed us to assess their level of relevant domain knowledge at least indirectly.

2. To estimate their technical skills relevant for working with the desktop videoconference, we asked them to answer a number of specific multiple choice questions on the extent to which they were using (a) the World-Wide-Web for information retrieval, (b) the Internet for communication via E-mail, chat, newsgroups, and (c) applications like MS Word, Exel, Powerpoint and other programs.

3. With regard to their prior experience with collaboration, participants were asked to classify themselves on a five-point rating scale (very much to hardly any). Next, they had to specify their collaborative experiences, by choosing from a list of alternatives including, where it had taken place (in school, at the workplace, in a sport team) and what the collaboration had been about, for example, solving a problem together, peer learning, reaching a joint goal.

For all three areas a minimum requirement was set and people who did not meet that requirement were excluded from participation. The remaining persons were grouped in to three levels of proficiency. Dyads were formed of people from the same level. The dyads were then randomly assigned to the four conditions, however, making sure to include an equal number from each level in each condition.
5.3 Setting

The two partner stayed in separate rooms for the entire experimental session. They collaborated computer-mediated. The computer-mediated scenario consisted of a desktop-videoconferencing environment (VCON, ViGO professional) including audio and video connection, personal text-editors and a shared text-editor (Wordpad shared with MS-Netmeeting). As you can see in the screenshot displayed in Figure 3 the two participants of a dyad could see the video picture of the remote partner on their individual computer screen. A continuous audio channel provided the possibility to talk to the remote partner. In addition, the shared text editor allowed to not only view, but also edit text jointly. The individual text editor allowed each partners to take notes and write individual text parts. The scenario supported synchronous verbal communication and joint activities (e.g. editing of the joint solution) as well as individual work phases.

*Figure 3. Screenshot of desktop videoconference setting*
5.4 Learning Phase: Experimental Conditions

The contents – relevant aspects of a good collaboration on the three levels macro, micro and domain specific – that were to be put across in the instructional conditions during the learning phase are summarized in Table 3. They were part of the exemplary collaboration that was introduced above (see represented in Figure 1). Table 3 is an essence of the characteristics of a good collaboration discussed in the theoretical part of the paper, and was used as the basis to design the model and to formulate the script. The following paragraphs describe in more detail what happened during the learning phase in each of the four conditions.

<table>
<thead>
<tr>
<th>Macrolvel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Time management (global and local)</td>
</tr>
<tr>
<td>2) Coordination of work</td>
</tr>
<tr>
<td>a) division of labor: content</td>
</tr>
<tr>
<td>b) division of labor: roles</td>
</tr>
<tr>
<td>c) technical coordination</td>
</tr>
<tr>
<td>3) Consideration of distribution of knowledge and material</td>
</tr>
<tr>
<td>(complementary expertise)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Microlvel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Function of content-related utterances</td>
</tr>
<tr>
<td>a) asking the partner about a new content (elicitation)</td>
</tr>
<tr>
<td>b) explaining the partner a new content (explication)</td>
</tr>
<tr>
<td>c) giving feedback</td>
</tr>
<tr>
<td>agreement</td>
</tr>
<tr>
<td>disagreement</td>
</tr>
<tr>
<td>further inquiry / clarification</td>
</tr>
<tr>
<td>2) Turn-taking</td>
</tr>
<tr>
<td>a) simultaneous talk (interruption)</td>
</tr>
<tr>
<td>b) explicit handover</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Domainspecificlevel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Diagnosis</td>
</tr>
<tr>
<td>a) list of symptoms from case description and relation to ICD criteria</td>
</tr>
<tr>
<td>b) decision for specific diagnosis (based on a)</td>
</tr>
<tr>
<td>2) Therapy</td>
</tr>
<tr>
<td>a) goals of therapy</td>
</tr>
<tr>
<td>b) therapeutic measures, psychotherapy (psychologist)</td>
</tr>
<tr>
<td>c) therapeutic measures, pharmacological treatments (medical doctor)</td>
</tr>
<tr>
<td>d) order of the measures</td>
</tr>
<tr>
<td>e) treatment ambulant or stationary</td>
</tr>
<tr>
<td>f) prognosis (difficulties to be expected, possible relapse or failure</td>
</tr>
<tr>
<td>of the therapy</td>
</tr>
<tr>
<td>g) additional therapeutic measures indicated (physiotherapy, rehabilitation)</td>
</tr>
<tr>
<td>h) assumed duration of the therapy</td>
</tr>
<tr>
<td>i) areas of responsibility of medical doctor and psychologist</td>
</tr>
</tbody>
</table>
5.4.1 Observational Learning from a Worked-Out Collaboration Example (Model Condition)

This experimental condition (henceforth called *model condition*) was realized in the following way: during the learning phase of the experiment, participants listened to recorded scenes of the collaborative problem-solving between a psychology student and a medical student on the first psychiatric case (case 1). The scenes were presented via audio recordings. In addition animated slide-clips allowed participants to observe the development of the joint solution in the text editors of the model collaborators.

Worked-out examples usually consist of a formulation of the problem, a description of the solution steps and the solution itself. Accordingly, the recorded scenes allowed the observing participants to follow the solution steps for the case problem at hand. In addition, the joint solutions for the diagnosis and the therapy plan presented as part of the model collaboration provided the participants with a model solution.

The model collaboration was delivered as a multimedia-presentation on the computer screen. A screenshot from the presentation is shown in Figure 4. The model setting resembled closely the desktop videoconference setting participants did later collaborate in: The text editors were located on the left hand side of the screen. On the right hand side of the screen, images symbolically representing the two model collaborators were positioned where the video picture of the partner could be seen in the later collaboration. During the presentation of the model collaboration, the two partners of each dyad were sitting separated from each other in those very rooms where they did later collaborate via the desktop videoconference.
To facilitate elaboration and learning from the worked-out collaboration example, the model presentation was accompanied by short instructional explanations displayed on the screen before and after each scene (see box in the middle of the screen). For example, an explanation was: “In the following scene you will hear how the two collaborators ask each other questions about the case. They make use of each others knowledge to clarify information given to them about the patient in the case description before they turn to the diagnosis”. A second example is provided in the screenshot. Further, self-explanation activities were prompted in the course of the model presentation. For example, after being presented with the model solution for the diagnosis participants were asked to discuss the important features of the solution with the partner via the desktop videoconference. Both the
instructional explanations as well as the self-explanation activities were expected to support a deeper processing of the worked-out collaboration example and, in consequence, learning.

5.4.2 Learning from Scripted Collaborative Problem-Solving (Script Condition)

During the learning phase, dyads in the scripted collaboration condition (henceforth called *script condition*) were provided with a detailed script prescribing specific phases for their interaction. The script was structurally equivalent to the worked-out collaboration example, meaning that participants in this condition actively engaged in the same collaborative phases that were presented to the participants in the model scenes. For example, while participants in the model condition listened to the model collaborators clarifying questions about the case, the participants in the script condition were asked to do this with their partner. Instructions in the script were given in the following way: “Please, use the following 7 minutes to ask your partner questions you might have about the case. Make use of each other’s knowledge to clarify information given to you about the patient in the case description before turning to the diagnosis.” Participants received the script instructions on paper.

5.4.3 Learning from Unscripted Collaborative Problem-Solving (Unscripted Condition)

To control for learning effects that of collaborative problem-solving without instructional guidance, this experimental condition (in the following called *unscripted condition*) was set up. Dyads collaborated freely during both the learning and the application phase.

5.4.4 Control Condition

A control condition was set up that was restricted to collaboration in the application phase. These dyads had no opportunity to gain experience in collaborating on the task during a learning phase.

The two instructional conditions, model and script, were compared to the control condition and the unscripted condition in order to assess the effects of systematic instructional intervention. Next, the effects of model and script were
contrasted to test the possible superiority of being instructed by a worked-out collaboration example. Finally, the performance under the control condition was compared to that under the unscripted condition in order to identify learning effects that might have resulted without systematic instruction.

5.5 Application Phase

The activity during the application phase was the same in all four conditions: computer-mediated collaborative problem-solving. Dyads collaborated via the desktop-videoconference system to formulate the diagnosis and to work out a therapy plan for the patient introduced in the second case. No further instruction or help was given in any of the conditions.

5.6 Procedure

The experiment was administered separately for each dyad. Overall, the experimental session took nearly six hours with a 24-hour break between the first (learning) phase and the second (application) phase. The first phase consisted of introduction, technical instruction and exercises (30 min.), overview of material for case 1 (20 min.), and experimental learning phase (120 min.) The second phase included overview of material for case 2 (20 min.), application phase (120 min.), and posttest (30 min.).

After the initial introduction, 30 minutes were allotted for a thorough introduction to the desktop videoconference system. Collaborative exercises with the system (not content related) ensured that the same level of proficiency of working with the system was reached for all participants.

During the learning phase, the experimental variation was implemented. Dyads in the model condition observed a worked-out collaboration example, dyads in the script condition solved the first case following a script prescribing specific work phases for their collaboration, and dyads assigned to the unscripted condition collaborated freely on solving case 1. Dyads assigned to the control condition were not involved in the experimental learning phase.

During the application phase, the collaborative task was the same in all conditions: developing a joint solution for case 2. Finally, an individual posttest was
administered. The test included questions about central aspects of a good collaboration and about important elements of a therapy plan.

5.7 Dependent Variables

The collaborative process during the application phase, its outcome the joint solution as well as the performance on an individual posttest were analyzed as dependent variables.

To gain information about the collaborative process during the application phase, two kinds of analyses were performed. The first analysis was based on activity patterns extracted from log-files taken during the application phase. Secondly, an in depth analysis of parts of the dialogs of all 36 dyads was performed at the macro level, as well as for a small sample of dyads at the micro level and at the domain specific level.

5.7.1 Collaborative Process: Logfile Analyses

On the basis of log-files taken during the application phase, the activity patterns of all 36 dyads were analyzed. Minute by minute it was noted, whether the partners talked with each other, whether they used the personal or shared text-editors, and whether text segments were exchanged. For a first analysis, individual and joint phases of work were identified from the activity patterns of all 36 dyads. The total amount of individual and joint work (in minutes) was summed up for each dyad.

As has been expounded above, particularly in the case of complementary expertise of the partners, a well-balanced proportion of individual and joint work phases is crucial for a successful collaboration. Allowing enough time for individual work is of central importance to ensure that the partners can bring their individual domain knowledge to bear. The instructional guidance provided by the model and the script condition followed the exemplary collaboration pattern represented in Figure 1. The phases of individual and joint work added up to about half of the time each (amount of individual work 57 minutes, amount of joint work 63 minutes).

Recent studies have provided evidence that individual work is often neglected in computer-mediated collaboration of the type analyzed in the present study (Hermann et al., 2001). Hence, the amount of individual work was of main interest in
the present study. Of particular relevance for the study’s rationale was the deviation of the collaboration during the application phase from the exemplary collaboration. If participants were able to learn from the model as well as the script this should become evident in smaller deviations. The match between exemplary collaboration and empirical collaboration patterns was analyzed by comparing the overall amount of individual work in the exemplary collaboration with the empirical data by computing the \textit{absolute differences between empirical data and exemplary collaboration for the amount of individual work}.

\subsection*{5.7.2 Collaborative Process: Analysis of Dialogs at the Macro Level}

A second approach to the collaborative process was taken by analyzing parts of all the dialogs with regard to coordinative (macro) aspects. The analysis was conducted to elucidate the collaborative process and the coordinative strategies used by participants in more depth than the logfile analysis could. The analysis of the macro level was run on the video recordings of all 36 dyads, but only on the diagnosis part of the dialogs. The decision for the diagnosis part was made, because the quality and correctness of the diagnosis was vital, and therefore representative, for the entire collaboration.

For the analysis of the macro aspects, criteria were developed allowing to assess relevant elements of the collaboration from the dialog (see Table 3: macro level). As has been shown in Table 2, these criteria were derived from the characteristics of good collaboration discussed in the introduction and implemented in the instructional material.

\textit{Time management} (1) was assessed both globally (e.g. whether partners mapped a plan for their general proceeding and arranged a timetable) and locally (e.g. whenever the partners referred to time and monitored the state of their work, and rearranged their timetable if necessary). Secondly, special attention was dedicated to assess good \textit{coordination of work} (2). Thereby coordination embraced the division of labor with regard to both content and person: who’s role (2b, \textit{division of labor: roles}) was to do what (2a, \textit{division of labor: content}). Further, talk about the \textit{technical coordination} of work was assessed in a separate category (2c), for example, when X asked Y to go ahead and copy her individual notes on the diagnosis in the shared text editor. Finally, explicit reference on the situation of complementary
expertise in the dyad was assessed (3, *consideration of distribution of knowledge and material*). Similar to the log file analysis, the macro-level dialog analysis was performed minute-by-minute: each minute was classified for the occurrence of the macro categories. Each minute could be classified for containing utterances on every category.

In addition to the macro-level analysis of all 36 dyads, micro-level analyses were performed on the transcribed dialogs of a restricted sample of eight dyads. Since these in depth analyses of only eight dyads do not allow for a comparison of the four conditions, the data are not presented in this paper. The same applies for the analyses of the domain specific dialog content.

### 5.7.3 Outcome

In order to analyze the quality of the joint solution of the second case, a system of quantitative criteria was developed by experts in the area of psychotherapy. Two experts, a clinical psychologist and a psychiatrist with medical background, jointly developed a prototypical solution for the second case. This solution was then reviewed and extended by more experts until an exhaustive solution had been reached. Of this final solution criteria were derived to assess the particular solutions of the participants. The elaboration of the diagnosis (justification of the diagnosis from case material) and the quality of the planned therapy were analyzed.

To justify a particular *diagnosis*, the ICD (International Classification of Diseases, Chapter V (F): Mental and Behavioural Disorders; World Health Organisation, 1993) provides diagnostic criteria – basically a list of symptoms, which a patient has to fulfill. Participants were expected to extract symptoms in support of their diagnosis from the case description and relate them to the diagnostic criteria listed in the ICD. For example, they may have quoted the patient’s strong feeling of hopelessness as one symptom relevant for the diagnosis “Moderate Depressive Episode”. In sum, 15 symptoms could be extracted from the case description and related to the diagnostic criteria of the ICD.

A good *therapy plan* required goals of the therapy to be specified, therapeutic measures to be planned and potential problems to be discussed. The therapeutic measures were expected to include both psychological as well as medical treatments. For the therapy score, the number of goals specified correctly, the number of
appropriate therapeutic measures listed as well as the number of relevant potential problems discussed, were summed up.

5.7.4 Posttest

The posttest on individual learning effects contained two subscales: (a) *metaknowledge about central aspects of a good collaboration* and (b) *knowledge about important elements of a good therapy plan*. Subscale A refers to literature-based assumptions on general (micro and macro) characteristics of a good collaboration in the given type of scenario. Participants were asked to describe important aspects that needed to be taken into account when collaborating in the present scenario. They were expected to name aspects such as the importance of continuously ensuring mutual understanding, of using the partner as a resource for clarification, of explicit coordination and division of work. A maximum of 7 points could be reached on this scale. Subscale B relates to a facet of the domain specific demands: the planning of the therapy. Participants were asked to describe what needed to be included in a thorough therapy plan. They were expected to name elements such as the necessity to specify the goals of a therapy before thinking about concrete measures, the importance of considering both psychotherapy and pharmacological treatments or the importance of discussing difficulties to be expected, like possible resistance of the patient, relapse or failure of the therapy. On this scale a maximum of 9 points could be reached (see Table 3, domain specific level, therapy).

5.8 Experimental Hypotheses

It was hypothesized that participants in the instructional conditions (model and script condition) would acquire deep understanding about relevant characteristics of good collaboration and corresponding collaborative skills during the learning phase. These skills were then expected to be revealed in the collaborative process during the application phase, in it’s outcome, the joint solution, as well as in the individual posttest (see Figure 2). Consequently, participants in the instructional conditions (model and script) were expected to outperform their control counterparts on all dependent variables: a better match of the amount of individual work with the
exemplary collaboration, better coordination as assessed from the dialogs, a better elaborated diagnosis, a better therapy plan, better metaknowledge about central aspects of a good collaboration, and better knowledge about important elements of a therapy plan. A slight advantage was expected for the model condition compared to the script condition. Further, we expected that the unscripted condition would not outperform the control condition.

6 Results

Comparing the four conditions, the results of univariate analyses of variance for each of the dependent variables are presented in a separate table below. All tests were based on a Type I error probability of .05. Eta-square effect-size estimates are provided for statistically significant effects. In accordance with our hypotheses, three a priori defined contrasts were computed for each dependent variable in case of a significant overall effect. First, the two instructional conditions were contrasted with the unscripted and the control condition (contrast 1). Secondly, the performance in the model condition was compared to the performance in the script condition (contrast 2), and finally, the unscripted condition and the control condition were compared (contrast 3).

As all the dependent measures on the quality of the joint solution and the posttest comprised a content analysis of freely formulated text, the reliability of the scoring procedure was safeguarded by having a second, independent judge score parts of the material. The correlation between the two raters was found to exceed .85 for all scales.

6.1 Collaborative Process: Logfile Analyses

From log-files taken during the application phase, a diagram depicting the pattern of activities over time was made for each dyad.

In Figure 5, one illustrative example for each of the four conditions is presented. The first diagram was taken from the model condition, the second from the script condition and the third and fourth from the unscripted and the control condition respectively. The activity pattern of the dyad from the model condition
shows clear-cut phases alternating between individual and joint work and a substantial amount of individual work. The dyad in the script condition also showed a well-structured pattern, however, particularly towards the end the work, phases become less distinct. Also, the amount of individual work of the script dyad is considerably lower than that of the model dyad. In the activity patterns of the dyads from the unscripted and the control condition, marked phases of individual or joint work cannot easily be identified and instead blend into a blurred pattern. Additionally, the amount of individual work was very low in these conditions.

To analyze the differences between the conditions with regard to the collaborative process statistically, individual and joint phases of work were identified from the activity patterns of all 36 dyads. The total amount of individual and joint work (in minutes) was added up for each dyad. As noted above, a well-balanced proportion of individual and joint work phases and, in particular, enough time for individual work is crucial for this type of interdisciplinary problem-solving. Since individual and joint work complement each other, only the results for individual work are presented. We analyzed the deviation from the exemplary collaboration by computing the absolute differences between the empirical and the exemplary amount of individual work time for each dyad.

A comparison of the four conditions (see Table 4) for this variable based on the data of all dyads revealed statistically significant differences in the overall test of a
univariate analysis of variance and in a comparison of the instructional conditions (model and script condition) with the conditions without instruction (unscripted and control condition). In accordance with our hypotheses, the deviations between exemplary prescribed amount of time and amount of time found empirically on individual (and joint) work were significantly lower in the conditions with instruction compared to the dyads that did not receive any instruction for collaborative problem-solving. There was a slight, but not statistically significant advantage for the dyads in the model condition compared to the script condition and more or less no difference between the unscripted and the control condition without any learning.

Table 4. Results on absolute differences between empirical data and exemplary collaboration for the amount of individual work

<table>
<thead>
<tr>
<th></th>
<th>Model condition</th>
<th>Script condition</th>
<th>Unscripted condition</th>
<th>Control condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 9 dyads</td>
<td>n = 9 dyads</td>
<td>n = 9 dyads</td>
<td>n = 9 dyads</td>
</tr>
<tr>
<td>( M^a ) (SD)</td>
<td>9.11 (8.12)</td>
<td>13.33 (11.35)</td>
<td>23.67 (14.20)</td>
<td>26.56 (18.08)</td>
</tr>
<tr>
<td>Contrast 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 -1 -1 -1</td>
<td></td>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>( F )</td>
<td>3.42</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( p )</td>
<td>.03</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \eta^2 )</td>
<td>.24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contrast 2</td>
<td>1 -1 0 0</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>( F )</td>
<td>9.60</td>
<td></td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>( p )</td>
<td>&lt; .01</td>
<td></td>
<td>.23</td>
<td></td>
</tr>
<tr>
<td>( \eta^2 )</td>
<td>.23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contrast 3</td>
<td>0 0 1 -1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( F )</td>
<td>0.44</td>
<td></td>
<td>.51</td>
<td></td>
</tr>
<tr>
<td>( p )</td>
<td></td>
<td></td>
<td>.65</td>
<td></td>
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<tr>
<td>( \eta^2 )</td>
<td></td>
<td></td>
<td>.65</td>
<td></td>
</tr>
</tbody>
</table>

\( a \) Mean scores on the absolute differences between empirical data and exemplary collaboration for the amount of individual work (in minutes). The higher the score is, the greater the absolute difference.

In order to gain a better understanding of this result we analyzed the variable “absolute differences between empirical data and exemplary collaboration for the amount of individual work” more closely. We found that these differences were higher in the conditions without instruction for two reasons:

1. The average amount of individual work of the dyads was lower in all conditions than the time spent on individual work in the exemplary collaboration (57 minutes). The difference was modest for the model condition, with an average amount of individual time of \( M = 53.00 \) minutes but substantial for the other conditions, with \( M = 44.56 \) minutes for the script condition, \( M = 39.11 \) minutes for the unscripted condition and \( M = 40.67 \) minutes for the control condition.

2. While the dyads in the model condition and also to some degree those in the script condition did not vary too much with regard to the amount of individual time (SD = 11.89 model condition, SD = 12.43 script condition), the unscripted and the control condition showed a great deal of variance with regard to this aspect (SD =
21.72 unscripted condition, SD = 28.64 control condition). These differences are statistically significant (Levene’s test on homogeneity of variances p < .01).

6.2 Collaborative Process: Analysis of Dialogs at the Macro Level

The comparison of macro categories (see Table 5) did only reveal significant differences among the four conditions for the coordination of the content-related division of labor. This overall significance is mainly due to the small amount of time in which the dyads of the unscripted condition spoke about the division of labor. But there is a consistent pattern also in the results for the other macro categories: It is interesting to note that on all macro categories the unscripted condition shows less activity than the other conditions. We will come back to this result in the discussion section.

<table>
<thead>
<tr>
<th>Table 5. Results on the analysis of the dialogs on the macro level a)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Time management</td>
</tr>
<tr>
<td>M (SD)</td>
</tr>
<tr>
<td>F</td>
</tr>
<tr>
<td>Coordination</td>
</tr>
<tr>
<td>Division of labor: content</td>
</tr>
<tr>
<td>M (SD)</td>
</tr>
<tr>
<td>F</td>
</tr>
<tr>
<td>Contrast 1</td>
</tr>
<tr>
<td>Contrast 2</td>
</tr>
<tr>
<td>Contrast 3</td>
</tr>
<tr>
<td>Division of labor: roles</td>
</tr>
<tr>
<td>M (SD)</td>
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<tr>
<td>F</td>
</tr>
<tr>
<td>Technical coordination</td>
</tr>
<tr>
<td>M (SD)</td>
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<tr>
<td>F</td>
</tr>
<tr>
<td>Consideration of distribution of knowledge/material</td>
</tr>
<tr>
<td>M (SD)</td>
</tr>
<tr>
<td>F</td>
</tr>
</tbody>
</table>

a) Mean scores on the macro categories. The scores indicate the minutes of dialog in which utterances on a category were detected.
6.3 Quality of the Joint Solution

With regard to the joint diagnosis, the overall test on differences between the four conditions yielded a statistically significant result (see Table 6). Dyads in the model condition on average produced a significantly better elaborated and justified diagnosis than dyads in the script condition. There was no difference between the unscripted and the control condition. The overall test also showed a significant result for the therapy plan (see Table 6). Dyads in both instructional conditions (model and script) produced a better therapy plan than dyads in the unscripted and the control condition. However, this time dyads in the script condition were slightly better than in the model condition. There was no difference between the unscripted and the control condition.

Table 6. Results on the quality of the joint solution

<table>
<thead>
<tr>
<th></th>
<th>Model condition ( n = 9 ) dyads</th>
<th>Script condition ( n = 9 ) dyads</th>
<th>Unscripted condition ( n = 9 ) dyads</th>
<th>Control condition ( n = 9 ) dyads</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diagnosis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>M</strong></td>
<td>8.89 (1.64)</td>
<td>4.39 (3.43)</td>
<td>6.50 (2.35)</td>
<td>6.28 (2.08)</td>
</tr>
<tr>
<td><strong>Contrast 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td><strong>Contrast 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>-1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Contrast 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>-1</td>
</tr>
<tr>
<td><strong>F</strong></td>
<td>5.06</td>
<td>&lt;.01</td>
<td>.32</td>
<td></td>
</tr>
<tr>
<td><strong>p</strong></td>
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<td>.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>( \eta^2 )</strong></td>
<td></td>
<td>.32</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Therapy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>M</strong></td>
<td>14.44 (4.30)</td>
<td>18.67 (6.97)</td>
<td>12.61 (4.57)</td>
<td>11.67 (3.34)</td>
</tr>
<tr>
<td><strong>Contrast 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td><strong>Contrast 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>-1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Contrast 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>-1</td>
</tr>
<tr>
<td><strong>F</strong></td>
<td>3.50</td>
<td>.03</td>
<td>.25</td>
<td></td>
</tr>
<tr>
<td><strong>p</strong></td>
<td></td>
<td>.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>( \eta^2 )</strong></td>
<td></td>
<td>.18</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\( a)\ Mean scores on the elaboration of the diagnosis. The higher the score is, the better the elaboration.

\( b)\ Mean scores on quality of the therapy plan. The higher the score is, the better the quality.

The importance of individual work for successful collaboration, which was discussed in connection with the collaborative process, is corroborated by the following result: the sample of dyads was divided into two subsamples according to the overall quality of their joint solution (diagnosis and therapy) by means of a median split, resulting in successful (M = 25.47, SD = 4.69) vs less successful (M = 16.25, SD = 3.45) dyads. Similarly, the sample was divided into dyads with “low” and “high” amounts of individual work by means of a median split (M\(_{low}\) = 27.83,
SD = 11.86; $M_{\text{high}} = 60.83$, SD=9.55). An analysis of frequencies ($\chi^2(1, N = 36) = 11.11$, $p = .001$) revealed that successful dyads were mostly to be found in the quadrant with the higher amount of individual work, whereas unsuccessful dyads were predominantly situated in the quadrant with the lower amount of individual work (see Table 7).

**Table 7. Frequencies of dyads for quality of the joint solution by amount of individual work**

<table>
<thead>
<tr>
<th>Dyads: Amount of individual work</th>
<th>Dyads: Quality of the joint solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>less successful: 14; successful: 4</td>
</tr>
<tr>
<td>high</td>
<td>less successful: 4; successful: 14</td>
</tr>
</tbody>
</table>

Note: Cells show frequencies of dyads for quality of the joint solution (variable divided by median split) by amount of individual work (variable divided by median split).

### 6.4 Posttest

The posttest results (see Table 8) revealed that participants in both instructional conditions significantly outperformed their control counterparts on the two subscales: (a) metaknowledge about central aspects of a good collaboration and (b) knowledge about important elements of a therapy plan. On both subscales, participants in the unscripted condition performed slightly better than those in the control condition.

**Table 8. Results on the two subscales of the posttest**

<table>
<thead>
<tr>
<th></th>
<th>Model condition</th>
<th>Script condition</th>
<th>Unscripted condition</th>
<th>Control condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n = 18$ subjects</td>
<td>$n = 18$ subjects</td>
<td>$n = 18$ subjects</td>
<td>$n = 18$ subjects</td>
</tr>
<tr>
<td><strong>Subscale A</strong> a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$ (SD)</td>
<td>3.14 (1.11)</td>
<td>3.06 (0.89)</td>
<td>2.33 (1.33)</td>
<td>1.67 (1.04)</td>
</tr>
<tr>
<td><strong>Contrast 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 -1 -1 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Contrast 2</strong></td>
<td>1 -1 0 0</td>
<td>0 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Contrast 3</strong></td>
<td>0 0 1 -1</td>
<td>1 -1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$F$</td>
<td>7.04</td>
<td>4.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p$</td>
<td>&lt; .01</td>
<td>.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\eta^2$</td>
<td>.24</td>
<td>.82</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Subscale B</strong> b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$M$ (SD)</td>
<td>4.06 (1.45)</td>
<td>4.11 (1.31)</td>
<td>2.31 (1.16)</td>
<td>1.94 (1.11)</td>
</tr>
<tr>
<td><strong>Contrast 1</strong></td>
<td>1 1 -1 1</td>
<td>0 1</td>
<td>1 -1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Contrast 2</strong></td>
<td>1 -1 0 0</td>
<td>0 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Contrast 3</strong></td>
<td>0 0 1 -1</td>
<td>1 -1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$F$</td>
<td>14.57</td>
<td>42.97</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p$</td>
<td>&lt; .01</td>
<td>&lt; .01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\eta^2$</td>
<td>.39</td>
<td>.39</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a) Mean scores on metaknowledge about central aspects of a good collaboration. The higher the score is, the better.

b) Mean scores on knowledge about important elements of a therapy plan. The higher the score is, the better.
7 Discussion

Summarizing the results on the log file analyses of the collaborative process during the application phase, both instructional conditions – and especially the model condition – resulted in a well-balanced proportion of individual and joint work. In comparison, dyads in the unscripted problem-solving and the control condition on average showed insufficient parallel individual work, and a great deal of variance with regard to this aspect. In other words, dyads in the control condition differed considerably in the way they collaborated. This phenomenon is widely known from the literature on collaborative problem-solving and learning: without support people differ greatly in the way they collaborate (for examples, see Johnson & Johnson, 1992; Slavin, 1995; Salomon & Globerson, 1989).

In comparing the results of the dialog analyses on the macro level for the four conditions, the striking result has to be explained that the number of utterances within these categories is consistently very low under the unscripted condition. In explaining this outcome two assumptions should be considered:

(1) More coordinative dialog is needed when collaborating for the first time.

(2) More coordinative dialog is needed for a good time management and a good coordination of work.

A consequence of the first assumption is that dyads in the control condition, collaborating on case 2 for the first time, should need more coordinative dialog compared to the three other conditions. The second assumption means that dyads in the instructional conditions (model and script) should show more coordinative dialog than the two other conditions. Taken both assumptions together, only the dyads in the unscripted condition should be characterized by a small number of coordinative utterances, which was in fact the case. In light of the two assumptions, the results of the control condition are difficult to explain.

It is important to keep in mind that the scores for the macro-level analysis presented here, were gained through a time-sampling procedure: each minute of dialog was classified for the occurrence of the macro categories. In other words, what we assessed here was the quantity, or intensity, of coordinative activity. In further analyses it would be desirable to not only count the amount of time of different
aspects of coordinative dialog, but to assess the quality of the dialog with regard to these aspects.

The results reported for the *quality of the joint solution* can be summarized by stating that dyads in the model condition yielded very good results on the diagnosis and good results on therapy planning. The script condition yielded heterogeneous results, below average on the diagnosis but outstanding for the therapy plan. There were no differences between the unscripted collaboration and the control condition without learning. The somewhat poorer performance of dyads of the model condition on the therapy planning may partly be explained by the observation that dyads in this condition collaborated with much enthusiasm and thus sometimes had problems with the time constraints for the task. While working on the diagnosis with great care and motivation, some dyads in the model condition did not have sufficient time left for the collaborative work on the therapy plan. In contrast, dyads in the script condition initially had problems coming to terms with the new situation in the application phase without clear advice on how to proceed on their collaboration. Consequently, it took them some time to really concentrate on the content questions of the case.

The *posttest* results are interesting as they add a different dimension to the results. While both the measures on the collaborative process and on its outcome, the joint solution, assessed collaborative skills implicitly, the posttest required explicit verbalization of knowledge about both general and domain specific aspects of the collaboration. The clear superiority of the instructional conditions on both subscales of the posttest implies that participants in the instructional conditions were not only able to profit from the instruction they received during the learning phase for their subsequent collaboration (as evident in the results on the process and outcome variables), but also with regard to the explicit knowledge they had acquired about important aspects of a good collaboration.

We had formulated the thesis that participants in the instructional conditions should outperform their unscripted and control counterparts on all dependent measures by having acquired relevant skills on collaborative problem-solving during the learning phase. Summarizing the results (see Table 9) we can assert that this was indeed the case: observational learning from a worked-out collaboration example as well as scripted collaborative problem-solving during the learning phase led to
collaborative skills, which became manifest in the subsequent collaborative process, its outcome and a posttest.

Table 9. Summary of results

<table>
<thead>
<tr>
<th></th>
<th>Model condition</th>
<th>Script condition</th>
<th>Unscripted condition</th>
<th>Control condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log file analysis on individual</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Analysis of dialogues on time</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>?</td>
</tr>
<tr>
<td>Management and coordination</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality of joint solution</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Diagnosis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Therapy plan</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Posttest</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Scale A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale B</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

The table summarizes the results on all dependent variables. In the table “+” denotes a positive result, “-” denotes a negative one, and “?” a result which is difficult to interpret.

Further, we had been interested in finding out whether an advantage could be detected for the model condition compared to the script condition. Apart from one subscale on the quality of the joint solution (diagnosis), the two instructional conditions were, however, not found to differ substantially. Overall, the script condition did better than expected.

With regard to a comparison of the unscripted and the control condition, it had been hypothesized that the condition with unscripted collaborative problem-solving during the learning phase would not outperform the control condition substantially in the application phase. Although dyads in the unscripted condition were in most cases slightly better than dyads in the control condition, the two conditions did not differ substantially. As discussed above, the results of the macro-level analysis fall out of line here. It can be concluded that learning only by collaborative problem-solving on a task is much less effective than systematic intervention and almost as bad as no opportunity for learning at all.

8 General Discussion

Desktop-videoconferencing settings are gaining in importance for remote collaborative problem-solving and learning (Finn, 1997; Whittaker, 1995). The
reasons for this development are manifold. Desktop-videoconferencing settings enable distributed partners to collaborate. The audio and video connection enables an immediate interactive contact. Shared applications like text documents and visualization tools help to focus the collaborative process and make it possible to reflect on its outcomes (Dillenbourg & Traum, 1999; Whittaker et al., 1993). Furthermore, they allow the integration of individual contributions of the partners into a joint work product. That way, complex tasks, which often require complementary knowledge of experts from different content areas, can be mastered with greater ease.

However, remote collaboration is not without challenges. For one, solving a complex task collaboratively, specifically the step-by-step solution of the task and its coordination, is a challenge in itself. In addition, computer-mediated communication of remote partners imposes specific challenges. The transmission of information has to be carried out in a much more explicit way. Collaborating partners often fail to complete their joint task or require too much time and effort. To guarantee efficiency, the collaboration has to be supported.

We have investigated methods to provide this support by taking an instructional approach. In the experiment presented, (1) observational learning from a worked-out example of a well-structured collaboration and (2) learning from scripted collaboration, were investigated as potential measures to promote the competence for interdisciplinary collaboration in a desktop-videoconference setting. An experimental paradigm was employed, investigating the learning effects of these instructional treatments in a subsequent collaboration. In sum, both methods showed positive effects on process and outcome of the collaboration during the application phase. While there was a slight advantage for observational learning, the learning effects of the scripted collaboration condition were better than expected.

The results lead us to draw the following conclusions:

Observational learning from worked-out collaboration examples is a successful way to promote collaborative skills. If such an example is well conceived, it functions as a model for the people observing the collaboration, especially if they have the possibility to reflect on what they see and listen to. The results of this study can be explained by and provide additional evidence for our thesis that observational
learning from a worked-out example of successful collaborative problem-solving is effective on two levels:

1. The task level: in the learning phase the participants acquire an elaborated understanding of how to solve tasks in the given domain. By observing and reflecting on the steps of the solution of the task (diagnosis and therapy plan for a given psychiatric case), they acquire domain specific problem-solving skills.

2. The collaboration level: the dyads further learn how to collaborate on a macro-level (division of work between partners, planning joint and individual working phases, ensuring the consistency of the work product).

To optimize observational learning from a worked-out collaboration example we suggest including short phases of active collaborative problem-solving. Bearing in mind findings from the literature on individual learning with worked-out examples (Stark, 1999; Stark, Gruber, Renkl & Mandl, 2000), we assume that a well-balanced mixture of observing solution steps and active problem-solving would yield the best results.

Cooperation scripts are a valuable means of supporting not only ongoing collaboration. Scripted collaboration can also trigger learning and thus promote collaborative skills. Partners who work jointly on a problem-solving task following a cooperation script acquire collaborative skills that also improve the collaboration in subsequent tasks. This result leads us to the conclusion that cooperation scripts should be considered more closely in future research as a promising instructional measure. As research on cognitive apprenticeship (e.g. Collins et al., 1989) has shown, complex cognitive skills can be acquired if performance is scaffolded externally in the beginning and the support is later faded out. It is our assumption that cooperation scripts can be designed to provide such scaffolding for collaboration. Referring to the cognitive apprenticeship method called “procedural facilitation of writing” (Scardamalia & Bereiter, 1985; Scardamalia, Bereiter & Steinbach, 1984), the cooperation script may be regarded as a “procedural facilitation of collaborating”. However, to script collaborative problem-solving with the objective of fostering the acquisition of collaborative skills yields much higher demands than merely optimizing the problem-solving outcome. The various elements of the script have to be reflected on and elaborated by the collaborating partners in order to fully understand their usefulness and to promote their internalization and
thereby their acquisition as a standard of subsequent collaborative work. This presupposes acceptance rather than reactance towards the script in the first place. Hence, the lack of motivation experienced by participants in the script condition of our experiment even at the beginning of the subsequent unscripted collaboration urges us to take the considerations and preliminary results on negative motivational effects of scripts (Bruhn, 2000; Hron et al., 1997; Kollar, 2001) very seriously.

The poor results of unscripted collaborative problem-solving on a subsequent task indicate that learning by doing is not very effective for computer-mediated collaborative problem-solving. The reason for this might be that the task is so demanding (the work on the psychiatric case itself, the collaboration, and the technical setting) that the cognitive overload impairs the solution process and learning.

It should be conceded that some dyads in the control conditions working without the experiences of a learning phase collaborated quite efficiently and with good success. However, the majority of the dyads only succeeded with good instruction. And we think that leading as many dyads as possible to successful collaboration should be the goal.

Finally, it should be emphasized that the present task is both realistic and of high practical relevance. On a general note: in many domains the enormous and rapid growth of domain-knowledge, in combination with an ever increasing specialization of this knowledge, has lead to a growing need for interdisciplinary collaboration. Experts from different fields of expertise are challenged to work together in order to succeed in solving the tasks at hand. As a result of this development, the investigation of collaboration between spatially distributed experts from different fields as well as the possible promotion of such collaboration have heavily moved in the focus of research activities. More specifically, the collaboration of psychologists and medical doctors on complicated cases is a daily challenge in German psychiatric hospitals. Often these collaborations are experienced as frustrating and unsuccessful (Tönnies, Breuer-Schneider & Schwieger, 1992). Both parties seem to lack in general collaborative skills (micro and macro level) and in competences for interdisciplinary dialog. We think that it is worthwhile to investigate ways of how to help psychologists and medical doctors to collaborate better. Results from this research may then be taken to include courses fostering understanding of and skills
for successful interdisciplinary collaboration in the medical and the psychological curriculum.

9 References


Acknowledgements

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Instructional Support for Computer-Mediated Collaboration:
Results from Process Analyses
Abstract

Support for collaboration in a computer-mediated setting was provided by instructionally promoting relevant collaborative competences. The two instructional measures investigated – learning by observing a worked-out collaboration example and learning from a scripted collaboration – were designed on the basis of a thorough analysis of what characterizes a good collaboration in the given scenario. To evaluate their effectiveness, an experiment was conducted. Not only the outcome of a subsequent collaboration and a posttest, but also the collaborative process itself were analyzed as dependent variables. The results give evidence of the potential of the two measures to promote collaborative competences. Compared to two control conditions, participants subsequently show a more sensible collaboration and achieve better results. This paper focuses on the results gained from process analyses of log-file data.
1 Introduction

Picture the following scenario: A medical doctor and a psychologist are asked to collaborate on solving a complicated clinical case. As the case involves both a physical illness and psychopathological symptoms, the assessment requires the two persons to make use of their complementary expertise. Their joint task is to formulate a report that includes a detailed diagnosis for the patient and a proposal of a suitable therapy. The two experts are not able to meet in person. Instead, they have decided to take advantage of a desktop videoconferencing system that has recently been implemented at both of their institutions.

In the given scenario the challenges of communication in a computer-mediated setting merge with the challenge to solve a complex task collaboratively, moreover, on the basis of complementary domain knowledge of the collaborating partners. In sum, the scenario can be expected to exert high demands on the collaborating partners due to its complexity. Sensible collaboration is indispensable to reach a good joint result.

But what aspects characterize a collaboration with prospect of success? On a “micro” level, crucial aspects of a good collaboration concern the communication (turn taking, feedback, mutual understanding; O’Conaill & Whittaker, 1997). Further, on a “macro” level the coordination of the joint work is of great importance (managing time, dividing labor, pooling unshared knowledge, balancing individual and joint work phases, integrating individual contributions; Hermann, Rummel & Spada, 2001; Johnson & Johnson, 1992). Allowing enough time for individual work is of great importance to ensure that the partners can bring their individual domain knowledge to bear. With regard to the demands specific to the task at hand, good collaboration moreover requires a specific sequence of steps.

The next question then is how these aspects may be conveyed to people? Many efforts to support collaboration in computer-mediated scenarios have been directed towards enforcing a fruitfully structured interaction (Hron, Hesse, Reinhard & Picard, 1997). Yet, these support strategies have been short-term interventions mostly directed towards immediate effects in a single collaboration. In contrast, we propose an instructional approach. We think that long-lasting effects could be
expected by systematically promoting collaborative competences of the people involved. But how might such an instructional approach look like, how should it be developed and evaluated? The central idea of our approach and the topic of this paper are illustrated in Figure 1.

2  Method

2.1  Instructional Measures

We have investigated two instructional measures to promote relevant strategies for a good collaboration: (1) Learning by scripted collaborative problem-solving, and (2) observational learning from worked-out examples of collaborative problem-solving.

2.1.1  Learning by Scripted Collaborative Problem-Solving

One possibility is to consider cooperation scripts (for an overview, see O’Donnell, 1999) as an occasion for learning and to investigate their effects beyond the scripted session. The idea is to provide a cooperation script during a learning phase in order to build up collaborative competences, which should become manifest in subsequent collaborations. While externally scripting collaboration over longer periods of time has been suspected to lead to motivational losses (Hron et al., 1997), learning from a scripted collaboration might be an effective instructional measure. This idea seems to be obvious, however, it has not yet been investigated systematically whether people may learn computer-mediated collaboration by following a script.
2.1.2 Observational Learning from Worked-Out Examples of Collaborative Problem-Solving

A second instructional approach is to have people observe and elaborate the successful computer-mediated collaborative solution of a problem. We call such a model of successful collaborative behavior a “worked-out collaboration example”.

Why do we expect worked-out collaboration examples to be effective in promoting collaborative competences?

Renkl (1997), VanLehn (1996) and others have emphasized that individual learning from worked out examples can be a successful way to acquiring cognitive skills. Worked-out examples in physics or mathematics consist of a formulation of the problem, a description of the solution steps and the solution itself. This type of learning is primarily based on the self-explanation of the solution steps (Chi, Bassok, Lewis, Reimann & Glaser; 1989). In industrial settings, a behavior modeling approach (Goldstein & Sorcher, 1974) has been shown to be an effective training method for the acquisition of complex behavioral skills. Moreover, observational learning has been proven to be of special value in the context of acquiring dialogue and discourse competences (Stenning et al., 1999).

Combining these different strands of research we expect that, reflecting on the solution steps of the worked-out example of a well-structured computer-mediated collaboration and on the behavior of the collaborating partners, observers could learn what aspects they need to pay attention to when collaborating.

2.2 Experiment

To test the effectiveness of our instructional approach to promoting relevant competences for a successful collaboration, an experiment was conducted comparing four conditions (see Table 1).

The experimental design comprised two phases, a learning phase and a subsequent application phase. During the learning phase, the experimental variation was implemented. The goal of the learning phase was the acquisition of collaborative competences. Effects of the experimental variation were then expected to become evident in the application phase, which was the same in all conditions. The outcome of the application phase – the joint solution, the results of a posttest, and aspects of
the collaborative problem-solving process during the application phase were investigated as dependent variables.

Table 1. Experimental design

<table>
<thead>
<tr>
<th>Model condition</th>
<th>Script condition</th>
<th>Unscripted condition</th>
<th>Control condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental learning phase (case 1)</td>
<td>Observational learning from a worked-out example of computer-mediated collaboration</td>
<td>Learning from scripted computer-mediated collaborative problem-solving</td>
<td>Learning from unscripted computer-mediated collaborative problem-solving</td>
</tr>
<tr>
<td>Application phase (case 2)</td>
<td>In all four conditions: Computer-mediated collaborative problem-solving (Dependent variables: collaborative process, outcome and posttest)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.2.1 Collaborative Task, Participants, and Setting

The collaborative task was the interdisciplinary solution of psychiatric cases with combined psychological and physical pathology. Dyads of advanced medical and psychology students were asked to jointly diagnose the patients described in the cases and to develop a suitable therapy plan making use of their complementary expertise.

72 students volunteered to participate in the study. 36 dyads, each comprising a medical student and a student of psychology, were set up and randomly assigned to one of the four conditions, resulting in a total of 9 dyads in each condition.

The computer-mediated scenario consisted of a desktop-videoconferencing environment (VCON, ViGO professional) including audio- and video-connection, personal text-editors and a shared text-editor (Wordpad shared with MS-Netmeeting). The scenario supported synchronous verbal communication and joint activities (e.g. editing of the joint solution) as well as individual work phases.

2.2.2 Experimental Conditions (Learning Phase)

Model Condition

During the learning phase of the experiment, participants in this condition listened to worked-out scenes of the collaborative problem-solving between a student of
psychology and a medical student on the first psychiatric case (case 1). The scenes were presented via audio recordings supplemented by animated slide-clips whenever the model collaborators did write something. As part of the model, the joint solutions for the diagnosis and the therapy plan were presented. To facilitate elaboration and learning, the model collaboration was accompanied by instructional explanations. Further, self-explanation activities were promoted by prompting collaborative self-explanation phases in the course of the model presentation.

**Script Condition**

During the learning phase, dyads in the script condition were provided with a detailed script prescribing specific phases for their interaction. The script was structurally equivalent to the worked-out collaboration example, meaning that participants in this condition actively engaged in the same collaborative phases that were presented to the participants in the model scenes.

**Unscripted Condition**

Learning effects may result from collaborative problem-solving without any model or script. To control for such learning effects, this condition was set up. Dyads collaborated freely during both, the learning and the application phase.

**Control Condition**

A control condition was set up, restricted to collaboration in the application phase.

### 2.2.3 Application Phase

The activity during the application phase was the same in all four conditions. Dyads collaborated via the desktop-videoconference system to formulate the diagnosis and to work out a therapy plan for the patient introduced in case 2. No further instruction or help was given in any of the conditions.

### 2.2.4 Hypotheses

It was hypothesized that participants in the instructional conditions (model and script condition) would acquire relevant collaborative competences during the learning phase. These competences were then expected to reveal in the collaborative process
as well as in the outcome of the application phase. Consequently, participants in the instructional conditions were expected to outperform their control counterparts on all dependent variables (collaborative process, joint solution of the case, posttest). A slight advantage was expected for the model condition compared to the script condition. With regard to the two other conditions, the unscripted condition should not significantly outperform the control condition, because of the high cognitive demands of unsupported collaboration in the learning phase.

2.3 **Theoretical Basis for Instructional Design and Assessment**

Theory-based guidelines were required as a basis for designing the instructional material of the worked-out collaboration example and the script, and for assessing the collaborative process of dyads from all conditions during the application phase. Integrating findings from relevant research characteristics of a good collaboration in the given scenario were identified on three levels, the “micro” level of the communication as such, the “macro” level of the coordination of the collaborative process, and the level of task specific demands on the joint work. The worked-out collaboration example and the cooperation script were designed to promote competences on all three levels: while the scenes of the worked-out collaboration example modeled good collaboration, the script instructed participants to act correspondingly.

2.3.1 **Micro Level: Communication on the Basis of Complementary Expertise**

At the “micro” level of the collaboration, the following aspects were identified to be important for a good collaboration: establishing and maintaining common ground (Clark & Brennan, 1991), exchanging unshared information (Stasser & Titus, 1985), using the partner as a resource for clarifications, asking comprehensible and relevant questions, formulating appropriate answers (Clark & Murphy, 1982), giving feedback about current state of understanding, and demanding further explanations if necessary.
2.3.2 *Macro Level: Coordination*

To ensure efficient work in the present scenario, it is crucial to coordinate the collaborative process in an appropriate way (Olson, Malone & Smith, 2001). Particularly in the case of complementary expertise of the partners – as in the scenario at hand – allowing enough time for individual work is of central importance to ensure that the partners can bring their individual domain knowledge to bear (Hermann et al., 2001). Thus, special attention was dedicated to model, respectively prescribe, good coordination and a well-balanced sequence of joint and individual work phases.

2.3.3 *Task-Specific Demands*

When solving psychiatric cases with combined psychological and physical pathology, specific “expert” procedures should be considered (Caspar, 1997). First of all, the diagnosis and planning of an adequate therapy need to be sequenced. Further, within each of the two components certain procedures should be followed: Participants were shown or instructed to justify their diagnosis by extracting confirmative symptoms from the case description. For a good therapy plan, participants were instructed to formulate goals for the therapy first, and then divide the task to think about concrete therapeutic measures: while the psychologist was to think mainly about psychotherapy, the medical student was to focus on the pharmacological treatment. Finally, they were required to discuss the individual proposals and jointly form a coherent and adequate therapy plan including both psychological as well as medical treatments, if applicable.

3 **Results and Discussion**

We analyzed the collaborative processes during the application phase, assessed the quality of the joint solution and asked participants to answer a knowledge posttest. In accordance with our hypotheses, three apriori defined contrasts were computed for each dependent variable in addition to an overall test of differences between the four conditions (analysis of variance). The two instructional conditions (model and script) were contrasted with the unscripted and the control condition (contrast 1). Secondly,
the performance in the model condition was compared to the performance in the
script condition (contrast 2). And, lastly, the unscripted condition and the control
condition were compared (contrast 3). All tests were based on a Type I error
probability of .05. While in a former paper (Rummel & Spada, accepted) we have
described the results on outcome and posttest in detail, this paper focuses on the
process analysis. Only a short synopsis on results on outcome and posttest is given.

3.1 Outcome and Posttest

To analyze the outcome (quality of the joint solution of the second case), a system of
quantitative criteria was developed assessing the elaboration of the diagnosis and the
quality of the therapy plan. With regard to the diagnosis, the overall test on
differences between the four conditions yielded a statistically significant result. In
particular, dyads in the model condition on average produced a significantly better
elaborated diagnosis than dyads in the script condition (contrast 2). Also for the
therapy plan, the overall test showed a significant result. Dyads in both instructional
conditions (model and script) produced a significantly better therapy plan than dyads
in the unscripted and the control condition (contrast 1).

The posttest on individual learning effects contained two subscales: (a)
metaknowledge about central aspects of a good collaboration and (b) knowledge
about important elements of a therapy plan. The posttest results revealed that
participants in the two instructional conditions significantly outperformed their
control counterparts on both subscales. In other words, the overall test on differences
as well as contrast 1 yielded significance.

3.2 Collaborative Process: Log-File Data

To gain information about the collaborative process, an analysis was performed on
the basis of log-files taken during the application phase. The activity patterns of all
36 dyads were extracted from these log-files. Minute by minute it was noted, whether
the partners talked with each other, whether they used the personal or shared text-
editors, and whether text segments were exchanged. These data were used for a
quantitative analysis of the collaborative process of the dyads. Individual and joint
phases of work were identified from the activity patterns of all 36 dyads.
For a first analysis, the total amount of individual and joint work (in minutes) was summed up for each dyad. As has been expounded above, in the case of complementary expertise of the partners, a well-balanced proportion of individual and joint work phases is crucial for a successful collaboration. Particularly a substantial amount of time for individual work is necessary to ensure that the partners can bring their individual domain knowledge to bear. In the instructional guidance provided by the model and the script condition, the phases of individual and joint work added up to about half of the time each (amount of individual work 57 minutes, amount of joint work 63 minutes).

Both instructional conditions – and particularly the model condition – showed a substantial amount of individual work, comparable to the one introduced to them during the learning phase via the instructional material (see Table 2). In comparison, dyads in the unscripted and the control condition on average showed much less individual work. This result does, however, not reach statistical significance, mainly because dyads in unscripted and the control condition showed a great deal of variance with regard to this aspect. The difference between the variances of all four conditions is statistically significant (Levene’s test on homogeneity of variances \( p=0.003 \)). This confirms a phenomenon well known from the literature on collaborative problem-solving and learning: without support people differ extremely in the way they collaborate (for example, Johnson & Johnson, 1992). The result further supports findings of Hermann et al. (2001) showing that individual work is in danger to be neglected in computer-mediated collaboration.

To corroborate this finding, the deviation of the empirically found amount of individual work during the application phase from the amount of individual work introduced in the instructional conditions was analyzed by computing the absolute differences (see Table 2). It was hypothesized that participants in the instructional conditions were able to learn from the model, respectively the script and therefore should show smaller deviations. The comparison of the four conditions for this variable revealed statistically significant differences in the overall test and in the comparison of the instructional conditions with the unscripted and the control conditions (contrast 1: \( p<0.01 \)). In accordance with our hypotheses, the deviations between the empirically found and the instructionally prescribed amount of time of
individual work were significantly lower in the conditions with instruction compared to the dyads which did not receive any instruction for collaborative problem-solving.

Table 2. Results of comparing the four conditions on the amount of individual work and on the deviation of this amount from the one instructed in the learning phase

<table>
<thead>
<tr>
<th></th>
<th>Model condition n=9 dyads</th>
<th>Script condition n=9 dyads</th>
<th>Unscripted condition n=9 dyads</th>
<th>Control condition n=9 dyads</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average amount</td>
<td>M (SD)</td>
<td>53.00 (11.89)</td>
<td>44.56 (12.43)</td>
<td>39.11 (21.72)</td>
<td>40.67 (28.64)</td>
<td>0.87</td>
</tr>
<tr>
<td>of individual work</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(minutes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deviation</td>
<td>M (SD)</td>
<td>9.11 (8.12)</td>
<td>13.33 (11.35)</td>
<td>23.67 (14.20)</td>
<td>26.56 (18.08)</td>
<td>3.42</td>
</tr>
<tr>
<td>(absolute differences)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tbody>
</table>

So far we have considered the amount of individual work as a whole. However, in an actual collaboration, this amount of time usually spreads over a number of phases. Comparing both the average number of phases and the average length of phases revealed the following results (see Table 3): The four conditions did not differ with regard to the average number of phases. Dyads in the two instructional conditions showed slightly longer phases of individual work. However, this result did not reach statistical significance.

Table 3. Results of comparing the four conditions on number and length of individual work phases

<table>
<thead>
<tr>
<th></th>
<th>Model condition n=9 dyads</th>
<th>Script condition n=9 dyads</th>
<th>Unscripted condition n=9 dyads</th>
<th>Control condition n=9 dyads</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average number</td>
<td>M (SD)</td>
<td>8.33 (2.55)</td>
<td>7.11 (3.79)</td>
<td>8.89 (3.66)</td>
<td>7.56 (4.00)</td>
<td>0.45</td>
</tr>
<tr>
<td>of individual work</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>phases</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average length</td>
<td>M (SD)</td>
<td>7.23 (3.62)</td>
<td>7.47 (3.37)</td>
<td>5.01 (3.88)</td>
<td>5.50 (4.43)</td>
<td>0.92</td>
</tr>
<tr>
<td>of individual work</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>phases</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In addition to the comparison of the four conditions, an analysis was performed comparing successful vs. less successful dyads with regard to average number and length of individual work phases (see Table 4). For this analysis the sample of dyads was divided into two subsamples according to the overall quality of their joint solution (diagnosis and therapy) by means of a median split: successful (M=25.47) vs. less successful (M=16.25). Comparing these two subsamples revealed that
successful and less successful dyads did not differ with regard to the average number of individual work phases. Successful dyads did, however, show significantly longer individual work phases. The importance of individual work for successful collaboration is further corroborated by the finding that the same result holds true when comparing the two subsamples regarding the total amount of individual work (see Table 4).

Table 4. Results of comparing successful vs. less successful dyads on number and length of individual work phases, and on the total amount of individual work

<table>
<thead>
<tr>
<th></th>
<th>Successful n=18 dyads</th>
<th>Less successful n=18 dyads</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average number of</td>
<td>M (SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>of individual work</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>phases</td>
<td>7.61 (2.95)</td>
<td>8.33 (3.96)</td>
<td>0.39</td>
<td>.54</td>
</tr>
<tr>
<td>Average length of</td>
<td>M (SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>individual work</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>phases (minutes)</td>
<td>8.31 (3.77)</td>
<td>4.30 (2.74)</td>
<td>13.30</td>
<td>&lt; .01</td>
</tr>
<tr>
<td>Average amount of</td>
<td>M (SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>of individual work</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(minutes)</td>
<td>55.00 (15.21)</td>
<td>33.67 (18.38)</td>
<td>14.43</td>
<td>&lt; .01</td>
</tr>
</tbody>
</table>

3.3 Discussion and Outlook

Summarizing the results on the collaborative process, dyads in the unscripted and the control condition tended to show not enough parallel individual work. Considering the relevance of individual work for the success of the collaboration this is not a trivial finding. Furthermore, it is worth noting that dyads in those two conditions showed a great deal of variance with regard to the amount of individual work, which means that they differed considerably in the way they collaborated. Some dyads collaborated quite efficiently and with good success without the experiences of a learning phase. However, the majority of dyads only succeeded with instruction.

It is an important finding that dyads implemented what they had learned in the temporal organization of their collaboration during the application phase. However, looking at the collaborative process by analyzing log-file data only opens up one perspective. This kind of data does not provide information about the contents of the dialogue. What has been talked about? Did dyads coordinate their collaboration explicitly and how much time did they spend on this? What did the “communicative
culture” of a dyad look like? Did the partners tend to interrupt each other? Did they give feedback about understanding? Did they refer back to their prior experience during the learning phase? To shed light on such questions, an in depth analysis of parts of the dialogues is currently being performed to further scrutinize the contents of the collaboration. The dialogues are being analyzed in two cycles: The focus of the first cycle is on the communicative (micro) and coordinative (macro) aspects of the collaboration. The second cycle concentrates on the content-related aspects of the utterances (topic, relevance, correctness). Results of these analyses will be part of the presentation at the conference.

4 References


Sustainable Support for Computer-Mediated Collaboration: How to Achieve and How to Assess It
Abstract

Innovative computer-mediated settings help override many traditional barriers to knowledge communication and collaborative work. But solving tasks and learning in collaboration remain difficult. The situation is aggravated in the particularly relevant and interesting case of complementary expertise of the collaborating partners. Then, remote computer-mediated collaboration constitutes a new third barrier on top of the two others because of the restricted possibilities for exchanging particular aspects of communication. To overcome these barriers, we propose a non-technical solution: to provide sustainable support for computer-mediated collaboration by instructional measures. The goal is to improve the collaborative skills and knowledge of the people involved in jointly working on a task. We outline different instructional approaches, tailored to a situation, in which experts from different fields jointly solve psychiatric cases thereby communicating via of a desktop video-conference. In addition, we develop assessment methods to evaluate the effects of these approaches on the quality of the collaborative process and the joint work product. An experiment bears evidence that computer-mediated collaboration can be improved by learning from a worked-out collaboration example and from scripted collaborative problem solving. We discuss the merits and problems of the assessment methods proposed, namely log-file analyses of the distribution of individual and joint work, quantitative dialog analyses of coordinative activities, of formal characteristics of the communication and of the domain-related dialog content. Further, the outcome measures are discussed.
1 Introduction

Innovative computer-mediated settings help override many traditional barriers to knowledge communication opening a wide array of opportunities for collaboration across distance, domain and expertise. In working contexts such as remote surgery, web design or the assessment of cases in international law firms the use of technology for remote collaboration is on the uprise (Leskovac, 1998; Nardi, Kuchinsky, Whittaker, Leichner & Schwarz, 1997; Whittaker, 1995). Unfortunately, computer-mediated settings cannot “just” be implemented for collaboration. Instantiating and sustaining common ground, pooling unshared knowledge, and coordinating collaboration are but a few of the profound difficulties in knowledge-rich communications which, in most computer-mediated environments are further impeded by restricted possibilities for exchanging nonverbal information. Without support, collaborating partners often fail to complete their joint task or find that it requires too much time and effort. The development of effective support measures depends upon a comprehensive theory of what constitutes good collaboration in a computer-mediated setting and how such collaboration can be achieved. In this chapter we discuss (1) barriers encountered in a computer-mediated collaboration setting, (2) different approaches to overcome these, and (3) methods to evaluate the support approaches by assessing their effects on process and outcome of the collaboration. Potentially sustainable support is provided by instructionally promoting the collaborative skills of the people involved. This approach is then implemented and tested in an experimental study. Finally, we summarize our findings on the support measures for computer-mediated collaboration and on the methods to analyze their effects.

2 Barriers to Successful Computer-Mediated Collaboration

Picture the following scenario: A medical doctor and a psychologist are asked to collaborate on solving a complicated clinical case. As the case involves both a physical illness and psychopathological symptoms, the assessment requires the two
persons to make use of their complementary expertise. Their joint task is to formulate a report that includes a detailed diagnosis for the patient and a proposal of a suitable therapy. The two experts are not able to meet in person. Instead, they have decided to take advantage of a desktop videoconferencing system that has recently been implemented at both of their institutions. The desktop videoconference enables them to see and hear each other while discussing the case at hand. Moreover, the system includes a shared workspace, which they can use to develop their joint report.

In the given scenario, the challenge to solve a complex task collaboratively, moreover, on the basis of complementary domain knowledge of the collaborating partners, merges with the challenges of communication in a computer-mediated setting. What characterizes the barriers that the people in this scenario face and how may these be overcome?

2.1 A First Barrier: Problem-Solving and Learning in Collaboration

Possible goals of collaboration, such as the exchange of distributed information, the joint solution of complex and ill-structured problems by experts from different fields, as well as collaborative learning in a new domain, require well-coordinated collaborative activities. Extensive research has shown that the success of collaborative efforts does not occur by itself (Diehl & Stroebe, 1991; Johnson & Johnson, 1992; McGrath, 1984; Slavin, 1995; Salomon & Globerson, 1989). Without systematic support people differ greatly in the way they collaborate, depending on a variety of interacting conditions like group size, group composition, collaborative task or the media used for communication (Dillenbourg, Baker, Blaye & O’Malley, 1995). Some groups collaborate quite efficiently and with good success even when let on their own. However, the majority of collaborations only succeed with adequate support.

2.2 A Second Barrier: Complementary Expertise as a Basis for Collaboration

In the scenario outlined above a second difficulty arises from the situation of “complementary expertise” of the collaborating partners. Interdisciplinary collaboration given a situation of “complementary expertise” can be characterized as follows: the partners of the collaboration complement one another in that each of
them possesses a relevant part of the unshared knowledge. Each of the partners is a “novice” in the other’s domain and an “expert” in his own. This can provide a prolific and promising basis for collaborative problem-solving. In fact, in many domains the enormous and rapid growth of domain-knowledge, in combination with an ever increasing specialization of this knowledge, results in a growing need for interdisciplinary collaboration. Experts from different fields of expertise are challenged to work together in order to succeed in solving the tasks at hand. Also, interdisciplinary collaboration is considered to be the key to a successful exploration of complex phenomena, where taking into account only one perspective would fall short (Gibbons et al., 1994; Kneser & Ploetzner, 2001; Ploetzner, Fehse, Kneser & Spada, 1999).

For example, the collaboration of psychologists and medical doctors is increasingly regarded to be of great importance and potential for the well-being of patients. A treatment with prospect of success is only possible if a correct diagnosis has been deduced from the symptoms of a patient. Yet, some symptoms can indicate both a somatic as well as a psychological diagnosis. For example, sleep disorders may be a symptom of depression but could also be a side-effect of pharmaceuticals prescribed for a certain disease. If a psychologist consulted a medical doctor before diagnosing some form of depression, this would certainly be advisable in the case of a patient who was currently taking medication for another medical condition. A further reason for the importance of interdisciplinary collaboration between psychologists and medical doctors is the high comorbidity of psychological and somatic disorders particularly among in-patients.

Despite all its potential, interdisciplinary collaboration is, however, not an easy undertaking (Lewis & Sycara; 1993; Bromme 2000). Problems known to be symptomatic for collaborative learning and problem-solving in general apply to an even greater extent to interdisciplinary collaboration (Thompson Klein & Porter, 1990; Stasser, Stewart & Wittenbaum, 1995). Instantiating and sustaining common ground (Clark & Brennan, 1991), pooling unshared knowledge (Stasser & Titus, 1985), and coordinating the collaboration (Barron, 2000) are but a few of the profound challenges to be met in this kind of collaboration. Interdisciplinary collaborators bring with them different domain knowledge, which comprises different concepts, methodological approaches, and cultures of thinking. Moreover,
many times interdisciplinary collaboration is burdened by naïve theories and prejudices about the partner’s domain. Also a well-known problem is that collaborators might fear their competence to be threatened. Last but not least, sometimes people do simply not want to collaborate as they have experienced collaborative work to be ineffective and troublesome.

2.3 A Third Barrier: The Challenge of Collaborating in a Computer-Mediated Setting

The situation of remote, computer-mediated collaboration has important consequences for the communication and the collaborative problem-solving process. On the one hand it constitutes a third barrier on top of the others: in computer-mediated collaboration the challenge of working collaboratively is aggravated by the constraints of an environment with restricted possibilities for exchanging particular aspects of communication. On the other hand remote communication settings also open chances of collaborating in new ways. The challenge of collaborating in a computer-mediated setting – we will discuss this third aspect of the scenario described above in more detail than the previous ones as it corresponds to the focus of this book.

What characterizes different settings for remote collaboration? How do they impact the communication? In what way do they constrain collaboration, and in what way do they promote it?

Collaboration settings can be distinguished regarding three aspects (see Table 1): (1) the channels available for communication (auditory – talking and hearing, visual – seeing each other, text-based – writing and reading), (2) the mode in which the collaboration takes place (synchronous, asynchronous), and (3) the way relevant material, like text documents or graphs, can be made available to the partners during collaboration (solely exchanging documents, or application sharing with simultaneous view on a document and possibility for joint editing). This systematization does not claim to be exhaustive, yet it comprises those aspects relevant for the considerations in the present chapter.

Which impact do the above characteristics have on the communication?
2.3.1 Channels Available for Communication

The possibility to talk to and hear the collaborating partners enables fast verbal interaction. The modulation of the voice further transports paraverbal information. Seeing then adds more aspects to the bandwidth of information available during communication: gestures and mimic provide nonverbal information, eye contact supports turn-taking processes; seeing moreover provides information about the availability and receptiveness of the counterpart. Talking, hearing and seeing, these communication channels are naturally used for synchronous collaboration.

In communication limited to writing and reading text messages, the exchange of nonverbal information is not possible in a usual way, which has severe effects on basic communication processes like turn taking, referencing and feedback mechanisms. The use of “emoticons”– symbols used to substitute nonverbal expressions (for examples see http://www.windweaver.com/emoticon.htm or http://www.pb.org/emoticon.html) – has developed as a way to partly overcome this barrier in text-based communication. Many text-based communication environments even provide extra tools to support interaction processes, which would otherwise be regulated by means of nonverbal information (Allmendinger, Troitsch, Hesse & Spada, 2003). For example, an environment might provide buttons to express basic emotional reactions (e.g. agreement or disagreement), and a button to signalize the wish to be the next “speaker”. But also the exchange of verbal information is impeded in text-based communication: writing text to express one’s ideas and opinions is generally found to require much more effort. One reason for this is of course that the act of handwriting or typing itself takes more time and effort. Another reason is given by the fact that written language is different, usually more formal, than spoken language. The enormous difference between communicating in writing versus speaking can be illustrated vividly by transcribing an oral dialog. Writing like one would speak seems inadequate and one gets the urge to formulate ideas more carefully in writing. This is particularly true for asynchronous collaboration (e.g. E-mail) and may be regarded as an advantage of this form of communication from another point of view. Text-based communication can also be used for synchronous collaboration, for example in a “Chat”-environment.
2.3.2 Mode of Collaboration

Then what are the characteristics of synchronous versus asynchronous collaboration (see Veerman & Veldhuis-Diermanse, 2001)?

Synchronous collaboration means the simultaneous presence (in the same place or remote) of the partners. The advantages of this mode of collaboration are high-frequent interactions, and the immediacy and spontaneity of responses. The downside of these characteristics is a high time pressure on responding, which may lead to insufficient information processing and, as a consequence, not well elaborated utterances. Particularly in text-based synchronous scenarios cognitive overload has to be expected as the simultaneous requirement to read, think about the read, develop a response and type it, very obviously exceeds human information processing capabilities. Synchronous collaboration scenarios further make it difficult not to work jointly during the entire collaboration, but to combine joint and individual work phases. The synchronicity often seduces collaborators to solely engage in joint activities and not allow for individual work (Hermann, Rummel & Spada, 2001). For some kinds of collaborations it is, however, indispensable for a successful solution of the collaborative task that each of the partners can bring his individual knowledge to bear. Yet, individual reflection is only possible in a situation without the immediate and continuous pressure to respond.

Such a situation is given in the case of asynchronous collaboration. Asynchronous collaboration is usually text-based. It is characterized by longer messages and by a lower frequency of interactions. Also messages tend to be written in a more formal style as characteristic in written language. The slower pace of the interaction without an immediate requirement to respond, allows for extensive information seeking activities and more elaborate, well-reflected responses as well as questions.

The characteristics described for synchronous versus asynchronous collaboration are closely related to the question of (parallel) individual versus joint phases of work during collaboration. It would be a fallacy to equate synchronous collaboration with only working jointly, particularly in the case of remote collaboration. The simultaneous temporal presence of collaborating partners may very well be used also for individual work phases, and sometimes this is of crucial importance for the task solution.
2.3.3 Joint Availability of Material

How does the way relevant material, like text documents or graphs, can be made available to the partners, impact the collaboration? In most collaborative settings it is possible to exchange individually prepared documents, which then become available to each individual during discussion. Usually, joint activities, which would allow simultaneous view on a document and joint editing are limited. In face-to-face settings taking notes on a sheet of paper or a flipchart visible to everybody simultaneously provide auxiliary solutions. Truly joint activities, however, do only become possible by means of modern application sharing technologies. These technologies open the chance for a joint manipulation of objects, data or documents (e.g. Word documents, Excel spreadsheets) in a workspace that is visible and accessible for all participants simultaneously (Dillenbourg & Traum, 1999; Gürer, Kozma & Millán, 1999; Whittaker, Geelhoed & Robinson, 1993). Such shared workspaces support the externalization and visualization of contents during discussion, problem-solving or learning. Functioning as an external memory for the collaboration, shared workspaces can reduce cognitive load during the interaction (VanBruggen, Kirschner & Jochems, 2002), may serve as a resource for the collaborative problem-solving process, and facilitate the construction of shared meaning. Thus, shared workspaces help to focus the collaborative process and make it possible to reflect on its outcomes. Furthermore, they allow individual contributions of the partners to be integrated into a joint work product. It should be noted, however, that shared workspaces also place demands on the coordination of the collaboration.

Table 1 classifies face-to-face collaboration and prototypical settings for remote collaboration on the three dimensions discussed above.

It becomes obvious from the table that desktop videoconference settings are particularly promising for remote collaboration as they appear to provide conditions most comparable to face-to-face communication, but with the additional advantages of modern application sharing technologies. In a desktop videoconference, participants in different locations each sit at their individual computer and communicate with one another via an audio-video connection. On the computer screen they can see video pictures of the remote partners. Each video picture is captured by a small camera sitting on top of the computer screen or placed directly at
the side of the screen. A continuous audio channel provides the possibility to talk to the remote partners. In addition, desktop videoconferences include facilities for application sharing, which adds the important element to not only be able to view, but also edit text or visual material jointly. In sum, video-mediated communication systems support complex synchronous interactions with an exchange of both verbal as well as nonverbal information (Finn, Sellen & Wilbur 1997).

Table 1. Characteristics of face-to-face collaboration and different settings for remote collaboration

<table>
<thead>
<tr>
<th>Communication</th>
<th>Additional features</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Making material</td>
</tr>
<tr>
<td></td>
<td>available</td>
</tr>
<tr>
<td></td>
<td>Auditory Text-based</td>
</tr>
<tr>
<td>Face-to-face</td>
<td>x x x x (x)</td>
</tr>
<tr>
<td>Chat</td>
<td>x x x x</td>
</tr>
<tr>
<td>E-mail</td>
<td>x x x</td>
</tr>
<tr>
<td>Video-conference</td>
<td>x (x) x x x</td>
</tr>
</tbody>
</table>

But is auditory and visual communication mediated via a desktop videoconference really like in a face-to-face situation?

Research in video-mediated communication has shown that communicational behavior in videoconference settings is different to that in face-to-face settings (Anderson et al., 1997; Doherty-Sneddon et al., 1997; O’Conaill & Whittaker, 1997). Depending on the quality of the audio and video transmission, delays in the transmission of sound and picture may cause specific communication problems such as breaks and overlaps in the dialog structure (Angiolillo, Blanchard,Israeli & Mané, 1997). But even with a very good technical quality, the expenditure of any form of collaborative activity in videoconferences is increased by an additional and more explicit effort (Anderson et al., 1997) concerning, for example, the processes of grounding (Clark & Brennan, 1991), turn-taking, or giving feedback. O’Conaill and Whittaker (1997) compared a low-quality videoconferencing system with a high-quality system and face-to-face collaboration. Contrary to their expectations, they found that collaborators in both video-mediated conditions tended to communicate differently than face-to-face collaborators. Apparently, the nature of the video-mediated communication was more “lecture-like”, e.g. handing over turns was done
in a formal way by using questions or naming the next speaker. One reason for this finding might be that the visual contact possible in desktop-videoconference settings is in most cases limited to seeing the face or upper body part of the partner; usually eye contact is not possible, neither is gaze awareness (Angiolillo et al., 1997; Joiner, Scanlon, O'Shea, Smith & Blake, 2002). It has also been criticized that joint awareness of and attention towards objects in the physical environment is not supported by videoconference systems (Kato et al., 2002). It can be concluded that despite the availability of audio and video the exchange of nonverbal and paraverbal clues remains impeded to some extent. The communicative process requires extra effort, good and explicit coordination is necessary.

Then what makes desktop videoconferences so appealing for the type of collaborative scenario we have described at the outset of this section? One indisputable advantage of desktop videoconferences is the possibility to share applications and thus work truly jointly. Secondly, the possibility to talk to and see the partner – even with its limitations – allows for high-frequent synchronous interactions and immediacy of responses. This is particularly important for collaboration on a task like the present that requires negotiation of concepts as well as individual ideas in discourse. With a view on the complementary expertise in the dyad it is, however, important to emphasize once more that remote synchronicity does not exclude individual work phases. Rather, particularly a desktop videoconference with the possibility to combine a shared application (e.g. a text editor) with an individual one (e.g. an individual text editor for each partner) offers ideal conditions to include both joint and individual work phases in a remote collaboration. Obviously, a collaboration setting restricted to text-based communication would be much less suitable as the combination of three kinds of text-based utterances (written dialog, individual text editor, joint text editor) would overstrain text processing capabilities.

Taking into consideration the three barriers altogether, the present collaboration scenario can be expected to exert high demands on the collaborating partners due to its complexity. Sensible collaboration is indispensable to reach a good joint result. Then the question to be answered next is: How to support the collaborating partners in achieving good collaboration?
3 Overcoming the Barriers: How to Achieve Good Collaboration

Having identified the challenges that need to be managed in order to collaborate successfully in a computer-mediated collaboration scenario of the type described at the outset, it is most important to think about ways to help collaborators overcome these barriers (see also Rummel & Spada, accepted).

Due to a lack of research on support measures for collaboration in desktop videoconference settings, the different support approaches which we propose draw on well-researched strategies for supporting face-to-face collaboration and various other forms of computer-mediated collaboration. Two general approaches to supporting computer-mediated collaboration can be distinguished: measures of support can be realized prior to or during the collaborative session.

3.1 Support During Collaboration

The approach of directly influencing interactions during an ongoing collaboration might be realized for one, by designing the environment (e. g. by configuring the interface in a specific way or by providing certain communication channels and shared applications). Secondly, several approaches have been directed at fostering fruitful collaboration by externally structuring the interaction process. Two of the most well-known techniques in the area of collaborative learning are reciprocal teaching (Palincsar & Brown, 1984) and scripted cooperation (O’Donnell & Dansereau, 1992). These techniques have the common feature that they prescribe work phases involving specific cognitive activities for the interaction of the collaborating partners (O’Donnell, 1999). For example, the reciprocal teaching technique designates roles to the collaborating learners, which include activities like questioning, summarizing, clarifying, and predicting (Palincsar & Brown, 1984). The main idea behind the use of cooperation scripts in computer-mediated environments is to focus the collaborative process on the most important subtasks and thus reduce the costs of coordination. Evidence for the effectiveness of scripting techniques to support face-to-face collaboration (O’Donnell & Dansereau, 1992; O’Donnell, 1999; Rosenshine & Meister, 1994), as well as collaboration in computer-mediated settings (Baker & Lund, 1997; Hron, Hesse, Reinhard & Picard, 1997; Reiserer, Ertl, &
Mandl, 2002) has been found in numerous studies. Usually, cooperation scripts in computer-mediated collaboration are implemented by giving step-by-step instructions. Further, in this context scripts are often implemented in the structure of the collaborative environment (e.g. Baker & Lund, 1997; Hron et al., 1997; Reiserer et al., 2002). This brings us to the aforementioned property of desktop-videoconferencing systems to make available shared workspace. The relevant idea here is that shared workspaces may be prestructured by embedding script information that can guide the collaborators and enhance content-specific negotiation in the workspace (“representational guidance”; cf. Suthers, 2001). Particularly in computer-mediated collaboration, an integration of both interface design and scripting the collaborative process becomes possible through this prestructuring of the communication interface (Bruhn, Fischer, Gräsel, & Mandl, 2000).

3.2 Support Prior to Collaborating: An Instructional Approach

Support implemented prior to the collaboration aims at promoting the collaborative competence of the people involved. In other words, collaboration strategies are taught in order to facilitate subsequent collaboration. We propose such an instructional approach, thinking that long-lasting, “sustainable” effects could be expected by instructionally promoting the collaborative skills of the people involved. But which instructional strategy is adequate to convey the relevant aspects of good collaboration to people and thereby promote collaborative skills for subsequent interactions? Direct instruction or training (Cannon-Bowers & Salas, 1998) would be the most obvious instantiation of this approach. However, a successful transfer of trained behavior to new application situations is doubtful (Mayer & Wittrock, 1996; Renkl, Mandl, & Gruber, 1996).

It might be more promising to follow a situated learning perspective (Collins, Brown & Newman, 1989; Greeno and MMAP, 1998; Lave & Wenger, 1991) and introduce collaborators to the “craft of collaborating” by immersing them in a corresponding environment, in other words by involving them in instructionally supported collaborative activities. The idea of a situated approach is that the learning situation should resemble the application situation as closely as possible. But how may we design a situation which allows people to learn to collaborate in a collaborative context that closely resembles the later application situation?
3.2.1 Learning by Doing: Unsupported (Unscripted) Collaborative Problem-Solving

One possibility is to involve people in collaborating on a task similar to the ones they will be confronted with later. In the present scenario, collaborating partners might thereby gain experience on at least three different levels: experience in performing the steps necessary to solve tasks of this type (problem-solving); experience in jointly working with the specific partner (collaborative problem-solving); and experience in communicating and working with the desktop-videoconference system (computer-mediated collaborative problem-solving). Such collaborative problem-solving without any additional help can be regarded as the most natural but also most restricted form of situated learning. It is doubtful that relevant learning processes would actually occur in such a situation without any help. Cognitive load theory (Sweller & Cooper, 1985; Sweller, VanMerriënboer & Paas, 1998) strongly suggests that the demands of problem-solving in such a complex situation might cause cognitive overload and lead to failure of both the problem-solving and the learning process. It can be expected that the present situation will be particularly likely to cause such overload, since the demands of solving the problem at hand are aggravated by the difficulties of working collaboratively, and in an interdisciplinary constellation, and by the challenges of computer-mediated interaction. At least learning this way is likely to lead to impasses and to be very time consuming.

3.2.2 Observational Learning from a Worked-Out Example of Collaborative Problem-Solving

A promising instructional strategy would be to have people observe the model of a successful computer-mediated collaborative solution of a problem. We call such a model a “worked-out collaboration example”. While observing, people should reflect on the solution steps of the worked-out example and on the behavior of the collaborating partners, thereby learning what aspects they need to pay attention to when collaborating.

Why do we expect a worked-out collaboration example to be effective in promoting collaborative skills? And how should such a model be designed in order to offer optimal opportunities for learning?
Reimann (1997), Renkl (1997), VanLehn (1996) and others have emphasized that individual learning from worked-out examples can be a successful way of acquiring cognitive skills. This type of learning is primarily based on the self-explanation of the solution steps (Chi, Bassok, Lewis, Reimann & Glaser; 1989). Sweller and Cooper (1985) have provided evidence, that learning from worked-out examples is often more effective compared to learning by problem solving due to cognitive overload caused by the demands of the situation of unguided problem-solving. In sum, the strengths of worked-out examples are to reduce cognitive load, to focus learners’ attention on relevant aspects of the problem-solving process, and to foster the acquisition of adequate problem-solving schemas (VanLehn, 1996).

How do these results on individual learning with worked-out examples transfer to our scenario? Why do we expect a worked-out example to be effective in promoting collaborative problem-solving skills?

Our assumptions are supported by a small strand of research, which has shown that observational learning can be of special value in the context of dialog and discourse. Stenning and colleagues (1999) have provided empirical evidence that the observation of dialogs supports the acquisition of dialog competence. Along the same lines, a study by Cox, McKendree, Tobin, Lee and Mayes (1999) analyzed the effect of reading the content of a tutor-student dialog with positive results on subsequent dialog.

Furthermore, in industrial settings a behavior modeling approach (Goldstein & Sorcher, 1974) based on observational learning (Bandura, 1977) has been shown to be an effective training method for the acquisition of complex behavioral skills (Latham & Saari, 1979, Meyer & Raich, 1983), similar to the collaborative skills we wish to convey.

Combining these different strands of research, we expect that observing the worked-out example of a well-structured computer-mediated collaboration and reflecting on the solution steps and on the behavior of the collaborating partners, constitutes a promising method to learn relevant aspects of what constitutes a good collaboration in the present scenario and acquire collaborative skills with long term effects.
3.2.3 Learning from Scripted Collaborative Problem-Solving

Our second instructional approach relates to an already introduced measure to support collaboration: cooperation scripts.

So far, cooperation scripts have mostly been implemented as short-term “online” interventions directed towards immediate effects in a single collaboration. But what are the long-term effects of cooperation scripts? Would it be possible to script collaboration over many sessions?

From an instructional point of view the central question is, whether the effects of cooperation scripts extend beyond the experimental session in which they were provided, by promoting the skills to collaborate. The idea is to consider cooperation scripts as an occasion for learning and to investigate their effects beyond the scripted session. While externally scripting collaboration over longer periods of time might lead to motivational losses (Bruhn, 2000; Kollar, 2001), learning from scripted collaboration might be an effective instructional measure. To our knowledge, it has not yet been investigated systematically whether people may learn computer-mediated collaboration by following a script.

4 Assessing Collaboration: How to Test Effects of Support Measures

With the goal to assess the effects of instructional support measures like the ones introduced above empirically, the important question arises which data sources would provide appropriate evidence. It has been criticized that most studies investigating the effects of support measures on computer-mediated collaboration have concentrated on either the collaborative process or the outcome (Anderson et al., 1997). In contrast, we believe it is necessary to include data from both the collaborative process itself as well as its outcome to evaluate the impact support measures may have. Assessing both sources of data further allows to gain insights into the relation between process characteristics and the quality of the outcomes of the joint work. Thereby the development of a theory of good computer-mediated collaboration can be promoted. Moreover, data on the individual benefits of support measures should not be forgotten; this kind of data could be collected e.g. by means of a posttest on knowledge of what constitutes good collaboration.
We propose an experimental paradigm to assess the effects of instructional support measures, which comprises two phases: a learning phase and a subsequent application phase (see Table 2). During the learning phase, the instructional support measures are implemented (=experimental variation). The selection of data sources for testing the effects of the learning phase is guided by the following considerations. If an instructional measure is successful, participants acquire knowledge of what aspects are relevant for a good collaboration and collaborative skills in the learning phase. Then, this knowledge and these skills should become evident in the subsequent application phase (which is the same in all conditions: computer-mediated collaboration without any further instruction or help) and in a posttest. The acquired collaborative skills should result in a better collaborative process during the application phase and thereby yield a better outcome (joint solution). An improved explicit knowledge about aspects of good collaboration and about the solution of the task should be further effects of the skill acquisition.

| Table 2. Experimental paradigm and data sources to test the effects of support measures |
|-----------------------------------------------|-------------------------------------------------------------|
| Learning phase | Implementation of support measures |
| Application phase | Assessment of effects |
| | → Data on collaborative process |
| | → Data on outcome (joint solution) |
| | → Data on individual knowledge |

In the following, we propose ways to assess performance at the three levels:

(1) The level of the collaborative process, reflecting the effects of collaborative skills acquired in the learning phase. (2) The level of the joint solution, representing the outcome of the collaborative process. And (3) the level of individual knowledge acquired in the learning phase. We take the scenario introduced at the outset as frame to describe these assessments. They are, however, by no means limited to this scenario, but may be applied to any computer-mediated collaborative settings with the same generic features. To resume our scenario shortly: A medical doctor and a psychologist collaborate on a complicated clinical case. Their joint task is to formulate a report that includes a detailed diagnosis for the patient and a proposal of a suitable therapy. The two experts collaborate via a desktop videoconference including audio- and video-connection, personal text-editors and a shared text-editor.
The shared text editor allows not only to view, but also to edit text jointly. The individual text editor allows each partner to take notes and write individual text parts.

4.1 Assessing Collaborative Process

In order to assess the collaborative process we are in need of theory-based assumptions on what aspects characterize a good collaboration. In lack of a comprehensive theory in the area of computer-mediated collaborative problem-solving, we have integrated empirical findings from different strands of research in our attempt to define aspects relevant for an assessment of good collaboration:

We distinguish between (1) a *macro* level assessing the coordination of joint work, (2) a *micro* level, assessing the communication: the way new content is introduced or asked for, feedback is given, and turn-taking is orchestrated, and (3) the *domain-related* content and quality of the dialog. The assessment methods developed for the macro and the micro level are not restricted to any specific domain. The domain specific assessment obviously has to be adjusted to the content domain of the collaboration.

In the following, we first outline the theoretical background of the three levels of assessment (Rummel & Spada, accepted). Then the system of criteria for assessing these levels of the collaborative process are introduced and discussed in detail.

On a “*macro*” level, the coordination of the joint work is of great importance (Barron, 2000; Olson, Malone & Smith, 2001; Malone & Crowston, 1990). Hereby, coordination has to serve several goals: managing time constraints, dividing the task into subtasks, dividing labor between the partners, balancing individual and joint work phases, integrating individual contributions. Particularly in the case of complementary expertise of the partners – as in the scenario at hand – the question of joint and individual working phases has to be considered (Hermann et al., 2001). What has to be prepared individually by applying disciplinary knowledge before integrating it into the joint solution? What elements of the preliminary joint solution are in need of a disciplinary reflection and revision? A well-balanced proportion of individual and joint work phases is crucial for a successful collaboration. Recent studies have provided evidence that individual work is often neglected in computer-mediated collaboration of the type analyzed in the present study (Hermann et al., 2001). Hence, the amount of individual work is of great interest for an analysis.
On a “micro” level, the communication (mutual understanding, feedback, turn taking; O’Conaill & Whittaker, 1997) is a crucial aspect of the collaboration.

Instantiating and sustaining mutual understanding is a constant challenge during the collaboration, a phenomenon widely known as “grounding” in communication (Clark & Brennan, 1991; Baker, Hansen, Joiner & Traum, 1999). When collaborating partners come from different disciplinary backgrounds, the establishment of a common ground and convergence (Roschelle, 1992) on central concepts is particularly important, yet also particularly difficult. In order to avoid misunderstandings it is indispensable to use the partner as a source for clarifications and ask appropriate (comprehensible and relevant) questions.

Asking questions is further of central importance to foster the exchange of unshared information. The pooling of unshared information (accessible only to individual members of the group) is one of the crucial aspects of successful collaborative problem-solving and decision-making (Stasser & Titus, 1985; Larson, Christensen, Franz & Abbott, 1998). The failure of collaborating partners to pool their unshared knowledge resources is devastating in a situation where the group members mutually depend on each other’s knowledge to successfully complete the group task (Johnson & Johnson, 1992). Such a situation arises in the present scenario through the distribution of complementary expertise in the dyad.

When tailoring one’s explanations to the knowledge of the partner, the pitfalls of an “illusion of evidence” (Jucks et al., 2003) have to be avoided. The importance of adjusting the level of questions (information asked for) and answers (information provided) is further supported by results summarized by Webb (1989). Only explanations at an appropriate level of elaboration can be of any help to the questioner.

The way two people regulate turn-taking during their interaction is a determining factor for the quality of the collaboration. How do the partners determine who will speak when, how do they regulate transitions, how explicit (verbal) or implicit (nonverbal) are the turn-taking cues they give each other, these are some of the questions in the scope of turn-taking (Sacks, Schlegloff & Jefferson, 1974). For instance, in computer-mediated communication settings explicitly handing over a turn can be a good solution to compensate for the reduced possibilities to transmit nonverbal information.
Last, but not least for a successful collaboration, the domain-related content of the dialog during collaboration has to be assessed and judged for its quality. In order to come to a good joint solution, particular topics have to be addressed during the interaction. Then, the way these topics are addressed differentiates between collaborations. In what breadth and depth was a topic discussed? Were the statements made adequate with regard to its relevance for the task solution? Were the statements correct? Was understanding established? Since the domain-related dialog topics required to solve a given task in a good way, strongly depend on the specific contents of the task, no general theoretical aspects can be discussed for this level of analysis.

To gain information about the collaborative process at the levels described above, we propose two approaches: An analysis on the basis of log-file data can provide information about a central aspect of the coordination of the collaboration: the pattern of individual and joint phases of work. Secondly, video recordings and transcripts allow an analysis of the dialogs with regard to aspects of all three levels: coordination (macro), communication (micro) and the domain-related verbal interactions of the partners.

4.1.1 Analysis of Activity Patterns

On the basis of log-files taken during the application phase, the activity patterns of the collaboration can be analyzed. The log-files which we have used in our research recorded minute by minute, what the collaborating partners were doing: whether they talked with each other, whether they used the personal or shared text-editors, and whether text segments were exchanged. An example of such an activity pattern is given in Figure 1.
From the activity patterns recorded in the log-files, individual and joint phases of work can be identified. Then, for example, the total amount of individual and joint work (in minutes) can be summed up. This allows to assess one aspect of the collaborative process on the macro level: the balance of individual and joint work. Further, if a collaborative task allows to sketch a normative, exemplary collaborative process with regard to the proportion of individual and joint work, the deviation of the collaboration during the application phase from this exemplary collaboration can be analyzed.

4.1.2 Analysis of Dialogs

A second approach to the collaborative process can be taken by analyzing the dialogs with regard to coordinative (macro), communicative (micro), and domain-related aspects. These analyses can be performed on different sources of data and for different units of analysis. The video recordings of the collaboration are one possible source of data. Since the video tape displays the collaborative dialog in real time, a minute is an appropriate unit of analysis. However, this data source is not suitable for more fine-grained analyses, e.g. at the turn level. From the video recordings, transcripts can be made make possible more fine-grained analyses.

Macro and Micro

For the analyses of the macro and micro aspects of the dialogs, we have developed a system of criteria drawing on the empirical findings on good collaboration as discussed above. The system allows to assess relevant elements of the collaboration from the dialog. Tables 3 and 4 give an overview of the categories assessed at the two levels (see also Groß Ophoff, 2003).

At the macro level (see Table 3), time management is assessed both globally (e.g. whether partners map a plan for their general proceeding and arrange a
timetable), and locally (e.g. whenever the partners refer to time and monitor the state of their work, and rearrange their timetable if necessary. Secondly, special attention is dedicated to assess good coordination of work (2). Thereby coordination embraces the division of labor with regard to both person and content: whose role (2b) is to do what (2a). Further, talk about the technical coordination of work is assessed in a separate category (2c); for example, when person A asks person B to go ahead and copy her individual notes on the diagnosis in the shared text editor. Finally, explicit reference on the situation of complementary expertise in the dyad is assessed (3). This concerns the distribution of both domain knowledge and text material. Parts of this system relate to the categories described by Bruhn and colleagues (Bruhn, Gräsel, Fischer & Mandl, 1997).

Table 3. System of criteria for macro level

<table>
<thead>
<tr>
<th>Macro level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Time management (global and local)</td>
</tr>
<tr>
<td>2) Coordination of work</td>
</tr>
<tr>
<td>a) division of labor: content</td>
</tr>
<tr>
<td>b) division of labor: roles</td>
</tr>
<tr>
<td>c) technical coordination</td>
</tr>
<tr>
<td>3) Reference on distribution of knowledge or material</td>
</tr>
<tr>
<td>(complementary expertise)</td>
</tr>
</tbody>
</table>

The system of criteria for the micro level analysis (see Table 4) assesses the communicative function of domain-related utterances: when the collaborators ask questions (1a), when explanations are formulated (1b), and when partners give each other feedback in the sense of showing agreement, disagreement or demanding further explanation (1c). Furthermore, the turn-taking behavior during the collaboration is assessed. It is noted when the partners talk simultaneously thereby interrupting each other (2a), and when they explicitly hand over a turn (2b).
**Table 4. System of criteria for micro level**

<table>
<thead>
<tr>
<th>Micro level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Function of domain-related utterances</td>
</tr>
<tr>
<td>a) asking the partner about a new content (elicitation)</td>
</tr>
<tr>
<td>b) explaining the partner a new content (explication)</td>
</tr>
<tr>
<td>c) giving feedback</td>
</tr>
<tr>
<td>agreement</td>
</tr>
<tr>
<td>disagreement</td>
</tr>
<tr>
<td>further inquiry / clarification</td>
</tr>
<tr>
<td>2) Turn-taking</td>
</tr>
<tr>
<td>a) simultaneous talk (interruption)</td>
</tr>
<tr>
<td>b) explicit handover</td>
</tr>
</tbody>
</table>

It should be noted that both the macro and the micro level include only categories unrelated to domain-specific content. Domain-related aspects are assessed separately.

**Domain-Related**

The focus of the domain-related analysis is on “topics” arising within the dialog. With the term “topics” we denote short, identifiable thematic segments within a dialog. A topic could be a discussion of on a specific symptom corresponding with a diagnosis. For example, in discussing about the possible diagnosis “depressive episode”, the symptom of constant fatigue described for a patient could be discussed – whether it might be resulting from the patient’s medication or be an indicator of a depressive episode. On the basis of a defined list of topics, the dialog of a given dyad is scanned to identify such topics. Each topic is further classified with regard to its general relevance for the solution of the case at hand, the adequacy of the way it was discussed, the correctness of the statements, and the depth of the discussion (see Table 5). For all topics, their relevance for the solution of the specific case at hand was defined beforehand. Finally, it is inferred from the dialog whether the partners reach mutual understanding when discussing a topic. The domain-related analysis was performed as part of the diploma thesis of one of our student’s (Schornstein, 2003).
Table 5. System of ratings for topics

<table>
<thead>
<tr>
<th>Relevance</th>
<th>Adequacy</th>
<th>Correctness</th>
<th>Depth of discussion</th>
<th>Mutual understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 = irrelevant</td>
<td>knowledge that does not contribute to the solution of the case</td>
<td>1 = adequate</td>
<td>the topic is discussed in a way contributing significantly to the advancement of the task solution</td>
<td>1 = superficial</td>
</tr>
<tr>
<td>2 = possible</td>
<td>theme that does not directly relate to the solution of the case, but might contribute to the understanding of the case</td>
<td>2 = inadequate</td>
<td>the topic is discussed in an insignificant way</td>
<td>2 = simple</td>
</tr>
<tr>
<td>3 = relevant</td>
<td>knowledge that needs to be brought up during discussion to allow for a successful solution of the task</td>
<td>3 = correct</td>
<td>only correct statements, or wrong statements corrected during discussion</td>
<td>3 = elaborated</td>
</tr>
<tr>
<td>Adequacy</td>
<td>1 = adequate</td>
<td>the topic is discussed in a way contributing significantly to the advancement of the task solution</td>
<td>2 = inadequate</td>
<td>the topic is discussed in an insignificant way</td>
</tr>
<tr>
<td>1 = adequate</td>
<td>the topic is discussed in a way contributing significantly to the advancement of the task solution</td>
<td>2 = inadequate</td>
<td>the topic is discussed in an insignificant way</td>
<td>3 = correct</td>
</tr>
<tr>
<td>2 = inadequate</td>
<td>the topic is discussed in an insignificant way</td>
<td>3 = correct</td>
<td>only correct statements, or wrong statements corrected during discussion</td>
<td>3 = correct</td>
</tr>
<tr>
<td>3 = inadequate</td>
<td>the topic is discussed in an insignificant way</td>
<td>3 = correct</td>
<td>only correct statements, or wrong statements corrected during discussion</td>
<td>3 = correct</td>
</tr>
</tbody>
</table>

Which data sources and which units of analysis should be used to perform these dialog analyses described?

Similar to the log-file analysis, the macro-level dialog analysis is performed minute-by-minute: each minute of dialog is classified for the occurrence of the macro categories. A minute can be classified for containing utterances on every category. As the timeframe of a minute is quite broad, the analysis does not require a transcription of the dialog, but can be performed on the video recording of a dyads’ interaction. To analyze dialog at the micro-level and the domain-related level, however, is not possible in a minute-by-minute analysis, but these fine-grained analyses have to be performed on the turn level resp. topic level, which can only be done from transcribed dialog. A summary of the levels of dialog analysis, their data source and unit of analysis is given in Table 6. All three types of dialog analysis are
very time consuming and require a great deal of work. Therefore, in most cases it will be necessary to perform them on a restricted sample and only for a selected part of the collaboration. On top of the expenditure of the analyses themselves, the time required for transcribing the dialogs should not be underestimated.

<table>
<thead>
<tr>
<th>Level of Analysis</th>
<th>Data source</th>
<th>Unit of analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macro</td>
<td>Video-recordings of dialog</td>
<td>Minute</td>
</tr>
<tr>
<td>Micro</td>
<td>Transcribed dialog</td>
<td>Turn</td>
</tr>
<tr>
<td>Domain-related</td>
<td>Transcribed dialog</td>
<td>Topic</td>
</tr>
</tbody>
</table>

### 4.2 Assessing Joint Outcome

Assessing the outcome in our type of scenario is to analyze a joint solution and judge its quality. In most instances the assessment of performance from a joint solution will comprise a content analysis of freely formulated text. Elements that denote a good solution have to be defined. Then the solution has to be analyzed for such elements. The sum of the elements could be an indicator for the quality of the joint solution.

For example, to analyze the quality of the joint solution in our scenario, a system of quantitative criteria was developed by experts in the area of psychotherapy. Two experts, a clinical psychologist and a psychiatrist with medical background, jointly developed a prototypical solution for the second case. This solution was then reviewed and extended by more experts until an exhaustive solution had been reached. From the final solution, criteria were derived to assess the particular solutions of the participants. The elaboration of the diagnosis (justification of the diagnosis from case material) and the quality of the planned therapy were analyzed.

To justify a particular *diagnosis*, participants were expected to extract symptoms in support of their diagnosis from the case description and relate them to the diagnostic criteria listed in the ICD (International Classification of Diseases; World Health Organization, 1993).

A good *therapy plan* required goals of the therapy to be specified, therapeutic measures to be planned and potential problems to be discussed. The therapeutic measures were expected to include both psychological as well as medical treatments.
4.3 Assessing Individual Knowledge

As argued above, we assume that instructional support measures should have the additional effects of increasing people’s knowledge about aspects characteristic for a good collaboration and a good solution of the task. Such effects could be assessed in an individual posttest. The posttest results can be very interesting as they add a different dimension to the results. While both the measures on the collaborative process and on its outcome, the joint solution, assess collaborative skills implicitly, the posttest requires explicit verbalization of knowledge about what constitutes a good collaboration and task solution.

In our case, the posttest on individual learning effects contained two subscales: (a) knowledge about central aspects of a good collaboration, and (b) knowledge about important elements of a therapy plan. Subscale (a) refers to some macro and micro characteristics of a good collaboration in the given type of scenario. Participants were asked to describe important aspects that needed to be taken into account when collaborating in the present scenario. They were expected to name aspects such as the importance of continuously ensuring mutual understanding, of using the partner as a resource for clarification, of explicit coordination and division of work. Subscale (b) relates to a facet of the domain-specific demands: the development of a therapy plan. Participants were asked to describe what needed to be included in a thorough therapy plan. They were expected to name elements such as the necessity to specify the goals of a therapy before thinking about concrete measures, the importance of considering both psychotherapy and pharmacological treatments or the importance of discussing difficulties to be expected, like possible resistance of the patient, relapse or failure of the therapy.

Since most of the analyses described above comprise an analysis of freely formulated text, the reliability of the scoring procedure should be safeguarded by having a second, independent judge score parts of the material.

5 Experiment

The purpose of this section is to give an example of an experimental study that has attempted to meet the challenge of assessing the effects of support measures on all three levels: collaborative process, joint outcome and individual knowledge. We
describe an experimental study that we have conducted (see Rummel & Spada, accepted) to test the effectiveness of the two instructional support measures we have developed: (1) observational learning from a worked-out collaboration example, and (2) learning from scripted collaboration. In the experiment, these two instructional conditions were compared to (3) learning from unsupported computer-mediated collaborative problem-solving (unscripted condition), and (4) a control condition without a learning phase. The experimental design is shown in Table 7.

**Table 7. Experimental design**

<table>
<thead>
<tr>
<th></th>
<th>Model Condition</th>
<th>Script Condition</th>
<th>Unscripted Condition</th>
<th>Control Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>**Experimental</td>
<td>Observational learning from a worked-out example of computer-mediated collaboration</td>
<td>Learning from scripted computer-mediated collaborative problem-solving</td>
<td>Learning from unscripted computer-mediated collaborative problem-solving</td>
<td>No learning phase</td>
</tr>
<tr>
<td>learning phase</td>
<td>(Case 1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>**Application</td>
<td></td>
<td>In all four conditions:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>phase (Case 2)</td>
<td></td>
<td>Computer-mediated collaborative problem-solving</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Dependent variables: collaborative process, outcome and posttest)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.1 Participants, Task, Material, and Setting

Collaborative task was the interdisciplinary solution of psychiatric cases with combined psychological and physical pathology. Dyads, each consisting of a medical student and a student of psychology, were asked to jointly diagnose the patients described in the cases and to develop a suitable therapy plan making use of their complementary expertise. In each condition 9 dyads were administered.

Two psychiatric cases were utilized in the experiment: case 1 for the learning phase and case 2 for the application phase. In both cases a psychological disorder coincided with some physical illness. Thus both cases made it necessary to take advantage of the complementary domain knowledge represented in each dyad. In order to make the correct diagnosis and map out an adequate therapy plan, medical as well as psychological aspects had to be considered.

Throughout the collaboration, dyads communicated via a desktop-videoconferencing system (VCON, ViGO professional) including audio- and video-connection, personal text-editors and a shared text-editor (Wordpad shared with MS-
Netmeeting). The scenario supported synchronous verbal communication and joint activities (e.g. editing of the joint solution) as well as individual work phases.

5.2 Experimental Conditions

5.2.1 Learning Phase

The following experimental variation was implemented during the learning phase (see Table 7).

**Model Condition**

Participants in this condition listened to recorded scenes of a collaborative “model” problem-solving between a student of psychology and a medical student on the first psychiatric case (case 1). The recorded scenes were presented in a multimedia presentation via audio supplemented by animated text, which showed the observers how the model collaborators developed the joint solution. Thus, the worked-out collaboration example modeled the solution steps necessary to solve the case and illustrated the joint solutions for the diagnosis and the therapy plan. To facilitate elaboration and learning, the model collaboration was accompanied by instructional explanations. Further, self-explanation activities were promoted by prompting collaborative self-explanation phases in the course of the model presentation.

**Script Condition**

Dyads in the script condition were provided with a detailed script prescribing specific phases for their interaction. The script was structurally equivalent to the worked-out collaboration example, meaning that participants in this condition did actively engage in the same collaborative phases that were presented to the participants in the model scenes.

**Unscripted Condition**

To control for learning effects of collaborative problem-solving without instructional guidance, this experimental condition (in the following called unscripted condition) was set up. Dyads collaborated freely during both the learning and the application phase.
Control Condition
A control condition was set up, restricted to collaboration in the application phase. These dyads had no opportunity to gain experience in collaborating on the task during a learning phase.

5.2.2 Application Phase
The activity during the application phase was the same in all four conditions: computer-mediated collaborative problem-solving. Dyads collaborated via the desktop-videoconference system to formulate the diagnosis and to work out a therapy plan for the patient introduced in the second case. No further instruction or help was given in any of the conditions.

5.3 Hypotheses
Participants in the instructional conditions were expected to outperform their uninstructed counterparts on all dependent variables: the collaborative problem-solving processes during the application phase, the quality of the joint solution, and the individual knowledge posttest. A slight advantage was expected for the model condition compared to the script condition due to motivational problems associated with the cooperation script. With regard to the two other conditions, the unscripted condition should not significantly outperform the control condition, because of the high cognitive demands of unsupported collaboration in the learning phase.

5.4 Dependent Variables and Assessment
The dependent variables were assessed as described in the previous section “Assessing collaboration: How to test the effects of support measures”. Table 8 gives an overview of the data sources and sample sizes of the analyses: For the outcome of the collaboration, the joint solution on diagnosis and therapy plan of all 36 dyads was analyzed. The knowledge posttest was answered individually, resulting in a sample size of 72 for this variable. An activity pattern like the one shown in Figure 1 was extracted from log-file data for each of the 36 dyads. These activity patterns were analyzed with regard to the amount of individual work (macro level). To elucidate the collaborative process in more depth than the log-file analysis could, our system
of criteria for assessment of the \textit{coordination} (\textit{macro level}) was applied to the video recordings of the dialog of all 36 dyads, however, only on the diagnosis part of the dialogs. The restriction of the analysis on the diagnosis part was necessary as the time required for an analysis of the entire dialog would have exceeded the possibilities of this study. The diagnosis part can be regarded as representative for the entire collaboration. The \textit{micro-level} categories were applied to the transcribed dialogs (diagnosis part) of a restricted sample of 8 dyads. The restriction of the sample was inevitable as the transcription of dialog is very time-consuming. The restricted sample of 8 dyads comprised two extreme dyads from each condition: one “successful” and one “unsuccessful” dyad as defined by the performance on outcome and posttest. The same restricted sample was used for the analysis of the \textit{domain-related} dialog (topics).

\begin{table}[h]
\caption{Overview of dependent variables and their assessment}
\begin{tabular}{|c|c|c|}
\hline
Dependent variable & Data source & Sample  \\
\hline
outcome & joint solution text on diagnosis and therapy plan & 36 dyads  \\
knowledge about good collaboration and solution & answers to posttest & 72 individuals  \\
collaborative process, macro: amount of individual work & activity patterns extracted from log-files & 36 dyads  \\
collaborative process, macro: coordination & video recordings & 36 dyads  \\
collaborative process, micro: communication & transcribed dialog & 8 selected dyads  \\
collaborative process, content: topics & transcribed dialog & 8 selected dyads  \\
\hline
\end{tabular}
\end{table}

\section*{5.5 Summary and Discussion of Central Results}

In the following, we give an overview of the central results on the different levels of assessment. For more details see Rummel & Spada (accepted).

\subsection*{5.5.1 Outcome}

The results for the \textit{quality of the joint solution} can be summarized by stating that overall dyads in the instructional conditions (model and script) outperformed their counterparts in the unscripted and control condition on both diagnosis and therapy
plan. There were no differences between the unscripted collaboration and the control condition without learning.

5.5.2 Knowledge Posttest

The posttest results revealed a clear superiority of the instructional conditions on both subscales of the posttest. This implies that participants in the instructional conditions were not only able to profit from the instruction they received during the learning phase for their subsequent collaboration (as evident in the results on the process and outcome variables), but also with regard to the explicit knowledge they had acquired about important aspects of a good collaboration.

5.5.3 Collaborative Process

Activity Patterns

Summarizing the results of the log-file analysis on the activity patterns during the application phase, both instructional conditions –and especially the model condition – showed a substantial amount of individual work. In comparison, dyads in the unscripted and the control condition on average showed much less and not enough parallel individual work. This result does, however, not reach statistical significance. As Levene’s test on homogeneity of variances revealed, the difference between the variances of all four conditions was statistically significant (p=0.003). For one, this led us to interpret the results of the analysis of variance with caution as one of the preconditions for this analysis is violated. Particularly important, however, are the implications of the results of Levene’s test for the interpretation of the collaborative processes. Especially dyads in the unscripted and the control condition showed an enormous amount of variance in the way they collaborated. This confirms a phenomenon well known from the literature on collaborative problem-solving and learning: without support people differ extremely in the way they collaborate (for examples, see Johnson & Johnson, 1992; Slavin, 1995; Salomon & Globerson, 1989). The result further supports findings of Hermann et al. (2001) showing that individual work is in danger to be neglected in desktop videoconference settings. In accordance with their findings, the average amount of individual work in all four
conditions was lower than the time of individual work in the instruction, and without instruction, dyads tended to work even less individually than with instruction.

To corroborate the above finding, the deviation of the empirically found amount of individual work during the application phase from the amount of individual work introduced in the instructional conditions in the learning phase, was analyzed by computing the absolute differences. It was hypothesized that participants in the instructional conditions were able to learn from the model and the script, and therefore should show smaller deviations. The comparison of the four conditions for this variable indeed revealed statistically significant differences in the overall test and in the comparison of the instructional conditions with the unscripted and the control conditions. In accordance with our hypothesis, the deviations between empirically found and instructionally prescribed amount of time on individual work were significantly lower in the conditions with instruction compared to the dyads, which did not receive any instruction for collaborative problem-solving.

**Dialog Analysis: Macro – Coordination of Joint Work**

In comparing the four conditions on their results of the dialog analyses on the macro level, the outstanding result is that the number of minutes that contain utterances within these categories was consistently very low under the unscripted condition as compared to the three other conditions, which did not show any remarkable differences.

Assuming that more coordinative dialog is needed when collaborating for the first time, this result for the unscripted condition is not surprising. The participants in this condition had already collaborated before and had therefore already gone through the process of coordinating their joint work once. Naturally, less coordinative activity could be expected during their second collaboration compared to dyads in the control condition, collaborating for the very first time during the application phase. But what is the reason that dyads in the instructional conditions (model and script) showed as many coordinative utterances as those in the control condition? Participants in these experimental conditions had been instructed that more coordinative dialog is needed for a good time management and a good coordination of work. It follows that dyads in the instructional conditions should show about the same amount of macro activities as the control group. However, the
macro activities that we see in these conditions would be expected to be of different and better quality than the activities in the control condition. But can we tell quantity and quality apart with our macro-level analysis? The answer is: no. We will come back to this issue in the concluding section.

A different approach to analyze the macro-level data was taken as part of a diploma thesis of one of our students (Groß Ophoff, 2003). In order to differentiate subgroups among the entire sample of 36 dyads, which showed distinctly different ways of coordinating their collaboration, Groß Ophoff performed a cluster analysis including all macro categories as well as the amount of individual work, which had proven to be an important factor of successful collaboration (see Rummel & Spada, accepted). The cluster analysis resulted in two distinct clusters of different sizes: the first cluster consisted of 8, the second of 27 dyads. One dyad was excluded as an outlier. Dyads in the first cluster showed more activity on all categories (time management, coordination of content, roles and technical aspects) except for the reference on the complementary expertise within the dyad. Moreover, the dyads of this cluster showed a substantially greater amount of individual work (in minutes), distributed over slightly more, but mainly longer individual work phases.

A t-test was performed comparing the two clusters with regard to their performance on one variable of the quality of the joint solution, the diagnosis. The result of the t-test showed a significant difference between the two clusters (t= 4.55; df= 26.37; p< .01): dyads in cluster 1 obtained much better results on the diagnosis than dyads in cluster 2. This result indicates that successful computer-mediated collaboration is characterized by explicit and efficient time management, technical coordination, and a sensible coordination of labor, including clear task division and the assignment of roles. Further, it seems that a substantial amount of individual work time is necessary to ensure that both partners can successfully bring their complementary domain knowledge to bear; merely addressing the distribution of knowledge in talking is not decisive.

**Dialog Analysis: Micro and Domain-Related**

Since the analysis of the communication with our micro level categories and the analysis of domain-related dialog content were performed only on 8 selected dyads (one “successful” and one “unsuccessful” dyad from each condition), the data does
not allow for a comparison of the four conditions. Descriptively comparing the results of the *successful* with the *unsuccesful* dyads did not reveal any reliable, systematic differences. Before we claim to extend this time costly analysis on the entire sample, however, we should weigh the cost and benefits that may be gained. We will come back to this point in the following section.

6 Instructional Support Measures and Methods of Assessment: Lessons Learned

In this section the results gained from the experimental study will be discussed in the light of two aspects. First, what do they tell us about the effects of our instructional support measures on computer-mediated collaboration. And, secondly, how appropriate were the methods of assessing process and outcome of the collaboration.

6.1 Instructional Support Measures for Achieving Good Computer-Mediated Collaboration

We had formulated the thesis that participants in the instructional conditions should outperform their unscripted and control counterparts on the dependent measures by having acquired relevant skills and knowledge on collaborative problem-solving during the learning phase. Summarizing the results we can assert that this was indeed the case: observational learning from a worked-out collaboration example as well as scripted collaborative problem-solving during the learning phase led to collaborative skills and knowledge about good collaboration. This became manifest in various, but not all aspects of the subsequent collaborative process, its joint outcome and an individual posttest. The results lead us to draw the following conclusions:

The poor results of the unscripted condition on the subsequent collaboration indicate that *learning from unsupported computer-supported collaborative problem-solving* is not very effective in promoting skills relevant for this kind of collaboration. The reason for this might be that the situation is so demanding (the collaborative work on the psychiatric case itself, the interdisciplinary communication, and the technical setting) that is prevents people from paying attention to and reflecting on the critical aspects of the collaborative process.
Observational learning from a worked-out collaboration example is a successful way to promote collaborative skills. If such an example is well conceived, it functions as a model for the people observing the collaboration. Yet, despite all their strengths, worked-out examples may lead to superficial processing of the example features and, in consequence, an illusion of understanding (Renkl, 1997). This danger could be counteracted by promoting the elaboration of the example, particularly by eliciting self-explanations (Renkl, Stark, Gruber & Mandl, 1998) and providing instructional explanations (Renkl, 2002). Similar as in research on worked-out examples, in the context of behavior modeling training (Goldstein & Sorcher, 1974), Decker (1984) has shown the importance of “learning points” – instructional explanations accompanying the model's behavior. It follows that in observing the worked-out collaboration example, participants should be guided to reflect on what they see and listen to.

Cooperation scripts can trigger learning about collaboration. Partners who work jointly on a problem-solving task following a cooperation script acquire collaborative skills and knowledge that also improve the collaboration in a subsequent task as well as its outcome. In future research, cooperation scripts should be considered more closely as a promising instructional measure and not only to provide support during an ongoing collaboration (Hron et al., 1997; Reiserer et al. 2002).

It should not be overlooked, however, that cooperation scripts may cause motivational problems since they often regulate the interaction in a strict manner. Following the motivation theory of Deci and Ryan (1985), which identifies self-determination as a major constituent of motivation, negative motivational responses of participants are to be expected. Kollar (2001) has presented preliminary results in support of this assumption. Motivational reactance towards the cooperation scripts might impede the internalization of the script as a standard for subsequent collaborative work. To counteract motivational problems which cooperation scripts may cause, the collaborating partners should be guided to reflect on the relevant features of the script in order to understand their usefulness.

In our current research we are addressing the issue of elaboration support discussed for both instructional measures: observational learning from a worked-out collaboration example and learning from scripted collaboration. By conducting an
experimental study comparing the effects of a model and a script with elaboration support and without such support, we want to scrutinize the importance of guiding meta-reflection about the instructional support measures. We are using the same experimental paradigm as in the study described in this chapter.

6.2 Methods of Assessing Process and Outcome of Collaboration

In evaluating the proposed methods of assessments, the focus is on the process analyses.

The *analysis of activity patterns from the log-file* data has shown to provide information about a central aspect of the collaborative process: the pattern of individual and joint phases of work. This information is particularly valuable as a balanced proportion of joint and individual work (Hermann et al., 2001) with a substantial amount of individual work (Groß Ophoff, 2003; Rummel & Spada, accepted) has proven to be an important factor of successful computer-mediated, interdisciplinary collaboration. From a practical point of view, this type of analysis has shown to be very feasible compared to the high expenditure required for the dialog analyses.

In evaluating the *analysis of dialog at the macro-level*, it is important to note that these score were gained through a time-sampling procedure: each minute of dialog was classified for the occurrence of the macro categories. In other words, what was being assessed was the quantity – or intensity – of dialog activity with regard to these aspects. The quantity of coordinative dialog activity is of interest, but its relation to the quality of the collaborative work is complicated. A substantial amount of coordinative dialog is necessary to structure the collaboration in an optimal way, particularly when working jointly for the first time. Too much coordinative dialog, on the other hand, reduces the time on the task itself, the time for domain-related dialog and writing. And again, assessing quantity does not mean to analyze quality. While speaking about time management or the coordination of work with regard to who and what is relevant in principle, counting the minutes of this type of dialog does not tell too much about the quality of the time management and the coordination of work. In fact, our system of criteria was formulated in a way that two minutes of successful dialog were counted in the same way as a miscarried coordinative dialog of the same length. So it would be desirable to complement this
quantitative measure by assessing the quality of the coordinative dialog in a more direct way.

A promising first step in that direction has been taken by a *qualitative content analysis* of the dialog (see Mayring, 2003) that was performed as part of a student’s diploma thesis (Sosa y Fink, 2003). The goal of this analysis was to identify aspects relevant for a successful collaboration by analyzing the collaborative problem-solving process. The dialogs of the 9 dyads in the unscripted condition were assessed. In an extensive analytic procedure the transcripts of four collaborative dialogs were condensed in several cycles of analysis until only thematic “headings” were left to describe the interaction. The headings from the different transcripts were integrated in one system. From this qualitative analysis, seven dimensions of the dialogs were identified to be constitutive for a good collaboration: (1) task alignment and performance orientation, (2) goal conformity, (3) self presentation and impression management, (4) coordination, (5) construction of a common knowledge base, (6) social competence, (7) structure of the problem-solving process. These dimensions were applied to characterize the dialogs of the 9 dyads in the unscripted condition.

To illustrate the content of these seven dimensions, the results of applying them to the dialog of a successfully collaborating dyad (dyad 34, see Sosa y Fink, 2003) are described in the following:

The partners of this dyad show a high *performance orientation* and joint *task alignment* (1). This is reflected in their high motivation as evident from the concentrated working on the case, and in the volitional control strategies they apply to maintain the motivation. Also, both partners work systematically towards achieving a high-quality outcome. They are critical of their own work and try to implement their thoughts efficiently and productively. Further, they show a distinctive belief in self-efficacy to be in control of the situation.

The partners concur in the *goals* they strive for (2) and work continuously and very systematic towards achieving those goals (goal-oriented).

They respect each other’s status of expertise (social identity) and seem to have agreed on an implicit working consensus, being “we are both here by choice; now, let’s be friendly with one another, do our best to jointly solve that task, and have a good time while doing it”. Thus, they show an open manner and treat one another
with patience and friendliness. These characteristics are all regarded as indicators for a good self presentation and impression management (3).

Their interaction is well-coordinated (4). Looking at the communication, they don’t interrupt each other, but are attentive to nonverbal turn-taking cues and hand over turns explicitly if necessary. Further they coordinate their interaction continuously: they monitor the time, divide the labor, and assign roles.

This leads over to the next dimension: The partners of this dyad work on developing a common knowledge base (5). They pool knowledge explaining their individual contributions, ask each other questions, and discuss. They assure mutual understanding when talking about certain content by giving explicit feedback. They take up each other’s contributions and build upon them.

The partners’ high social competence (6) in the dialog shows by the way they handle doubt and insecurity as well as misunderstanding and conflict. As mentioned before they deal with each other in an open and patient way. Disagreement and slight tensions are met in a humorous and ironic way.

The collaborative problem-solving process (7) includes important phases like brainstorming and exchanging first impressions about the case, collecting and trying to clarify questions, developing solution parts individually, then discussing the individual proposals; finally, coming to a consensus decision and integrating the individual parts in a coherent joint solution.

Applying these seven dimensions as a frame of analysis to the entire 9 dyads in the unscripted condition has shown promising results: the dimensions seem to be adequate to distinguish successful vs. less successful collaborations. Currently, the system is crossvalidated by applying it to another sample of dyads from the experiment.

As discussed for the macro-level analysis, we should keep in mind that counting the occurrence of utterances on the micro level in the way we have done it, does not give clear evidence on the quality of these utterances. Our system of criteria for the micro level was developed to serve as an assessment tool which is not domain specific, “content-free”, and easy to apply. Yet, maybe also to assess the characteristics of the communication, a more qualitative, content-related approach of analysis would be better suited. After all, we should question if the micro communication features of an interaction are in fact such a significant indicator for
the success of a collaboration. It might well be that the relevance of this level for the collaboration has been overestimated. Basic features like turn-taking, giving feedback (especially in the sense of backchanneling), asking for information or explaining something to somebody are characteristic for everyday communication. If problems occur at this level, they may have to do more with long established individual differences in communicating, than with new problems arising from computer-mediated collaboration. Moreover, our participants were certainly well aware that they are collaborating in an “experimental”, new situation that requires specific attention being paid to these aspects.

The assessment of individual knowledge about central aspects of a good collaboration and about one aspects of the domain, namely important elements of a therapy plan, did not pose problems. Due to the complexity of the domain, assessing the quality of the joint solution (the diagnosis and therapy plan) was not as easy. Cases like the ones used in our experiment can be seen under different aspects. Although our system of criteria to evaluate the joint diagnosis and the planned therapy was developed by experts, the assessment of the particular solutions by the dyads was not always a straightforward application of the criteria.

To summarize: Instructional support measures for achieving good computer-mediated collaboration were developed and applied successfully. Learning from a worked-out collaboration example and learning from scripted collaborative problem-solving improved collaboration and its outcome. The assessment methods that were developed to analyze the amount of individual and joint work, the coordinative dialog, characteristics of the communication, and to categorize the domain-related content of the dialogs should be complemented by a qualitative content analysis, which allows to evaluate the quality of the dialog more directly.

7 References


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Can People Learn Computer-Mediated Collaboration by Following a Script?
Abstract as Printed in Proceedings

There is ample empirical evidence that cooperation scripts are effective measures for supporting both face-to-face and computer-mediated collaboration (CMC). Following the motivation theory of Deci and Ryan (1985), which identifies self-determination as a major constituent of motivation, cooperation scripts may, however, cause motivational problems, since they regulate the interaction in a strict way. Similar considerations have been made by researchers who have successfully applied scripts to enhance CMC. So, if collaboration can not be scripted over many sessions the question then is, whether the effects of a cooperation script outlast the experimental session in which it was provided by promoting collaborative competences.

Our hypothesis is that scripted CMC can also trigger learning: Partners who jointly work on a problem-solving task following a cooperation script are expected to acquire collaborative skills, which improve the collaboration also in subsequent tasks.

In an experimental study, a cooperation script was provided in a first CMC during the learning phase to build up collaborative competences, which were then expected to become evident in process and outcome of a second, unscripted CMC during the application phase. Compared to three other conditions – an observational learning condition, a condition with unscripted collaboration during the learning phase and a condition without a learning phase, the script showed positive effects on process and outcome during the application phase. This leads to the conclusion that given an appropriate didactic design, cooperation scripts seem to constitute a promising means to provide support in computer-mediated collaboration with long-term effects by promoting collaborative competences.
1 Introduction: Cooperation Scripts

There is ample empirical evidence that cooperation scripts are effective measures for supporting both face-to-face (e.g. Huber, 1999; O’Donnell & Danserau, 1992; O’Donnell, 1999) and computer-mediated collaboration (e.g. Baker & Lund, 1997; Härdler, 2003; Hermann, 2001; Hron, Hesse, Reinhard & Picard, 1997; Reiserer, Ertl & Mandl, 2002; Weinberger, Fischer & Mandl, 2003).

What are cooperation scripts? The central idea of implementing a cooperation scripts is to foster fruitful collaboration by externally structuring the interaction process. Collaborating partners are guided through a sequence of interaction phases. For each phase specific activities are prescribed like roles in a theater or movie script. The script is expected to prompt cognitive and social processes by participants that might otherwise not occur. This holds true even though there are great differences in the specific ways cooperation scripts have been realized as will become evident in the following sections. We present some illustrative examples of cooperation scripts from different areas of research. In this we follow the line of argumentation taken by Kollar, Fischer & Hesse, 2003. In their paper they contrast cooperation scripts as investigated in traditional collaboration research with cooperation script that have been developed to provide support for collaboration in computer-mediated collaboration. We end this section by discussing ways to characterize cooperation scripts by carving out their generative features. We describe two attempts for such classification systems: The syntax and semantics of CSCL scripts proposed by Dillenbourg (2002) and the dimensions of computer-supported cooperation scripts put forward by Kollar et al. (2003). In the second section we discuss possible pitfalls and drawbacks of cooperation scripts. In the third section, we introduce our own cooperation script with its instructional rationale and the experimental paradigm it has been investigated with (Rummel, Ertl, Härder & Spada, 2003; Rummel & Spada, in press). Then we try to apply the two classification approaches by Dillenbourg and Kollar et al. to characterize the central features of our cooperation script. Finally, the central results gained from our experimental study are evaluated in the light of the key question of this paper: Can people learn computer-mediated collaboration by following a script?
1.1 Cooperation Scripts in Traditional Collaboration Research

1.1.1 Scripted Cooperation: Danserau & O'Donnell.

One of the oldest and most well-known approaches to providing a script in order to structure cooperative processes is the so-called MURDER script developed by Danserau and colleagues (Danserau, 1988; O'Donnell & Danserau, 1992; for an overview see O'Donnell, 1999). This script is directed at helping two college students in learning collaboratively from text material. The script includes detailed instruction on how to proceed in jointly processing the text at hand. At the outset, the text is broken into sections. Then students first read a section individually. Next, they take turns in the role of the recaller (summarizing the major ideas of the passage) and the listener (monitoring the explanation: detecting errors, identifying omissions and asking for clarifications. Together the partners elaborate on the contents of the section and try to make it more memorable by connecting it to previous knowledge or “mnemonic” illustrations like images or analogies. This cycle is repeated for each section of the text. Finally, the students review the text once more. In sum, the central activities prompted by the cooperation script are (see O’Donnell, 1999): the overt verbalization of thinking about the text, the metacognitive activities involved in active listening (e.g. error detection), and the emphasis on continuous elaboration. Further, cross-modeling among the two peers is an important element.

1.1.2 Reciprocal Teaching: Palinscar & Brown

Similar to the Scripted Cooperation approach Danserau and O'Donnell, the script developed by Palinscar & Brown (1984) provides support for the collaborative processing of text. The main difference to the Scripted Cooperation procedure is that the Reciprocal Teaching technique was developed for the classroom. The teacher and different students take turns performing the different steps of the script. Thus, the teacher provides an “expert model”, especially in the beginning. As the students become more proficient, the teacher retreats and the cross-modeling among peers becomes more and more important. The Reciprocal Teaching script involves four main activities: formulating questions on the text, summarizing, clarifying
difficulties with the text, and making predictions about how the text will continue. These steps are repeated for the different passages of the text.

1.1.3 Guided Peer Questioning: King

The goal of the Guided Peer Questioning method by King (e.g.1997, 1998, 1999, 2002) is to support learners discussing some learning material in a small group by promoting the use of questions. For different types of questions, “content-free open-ended questions starters” (King, 1999) are provided to the students. For example: What does…mean?, What would happen if…?, How are…and…similar? The students use these questions starters to formulate their own specific questions. The questions starters are provided on little cards handed to the students at the outset.

1.2 Cooperation Scripts in CSCL Research

While computer-mediated settings provide great chances for new forms of collaboration across distance, time, and level and domain of expertise, the use of such settings for collaboration has important consequences. The challenge of working collaboratively is aggravated by the newness of the setting and the constraints of an environment with restricted possibilities for exchanging particular aspects of communication (like nonverbal information or gaze). Difficulties arise concerning issues like instantiating and sustaining common ground, pooling unshared knowledge, and coordinating collaboration. Support may be provided by cooperation scripts which can alleviate the burden of coordination on different levels.

In the context of computer-mediated collaboration, scripts are often implemented in the structure of the collaborative environment (Rummel et al, 2003). The relevant idea here is that shared workspaces may be prestructured by embedding script information that can guide the collaborators and enhance content-specific negotiation (“representational guidance”; cf. Suthers, 2001). Especially in computer-mediated collaboration, an integration of both interface design and scripting the collaborative process becomes possible through prestructuring the communication interface (Bruhn, Fischer, Gräsel, & Mandl, 2000; Hesse, Garsoffsky & Hron, 1997).
1.2.1 Structuring the Interaction by Designing the Interface

The cooperation script implemented by Hron et al. (1997), regulated the interaction of two people in a text-based computer-mediated setting. Collaborative task of the dyad was to perform corrections on a diagram depicting some biological structure. The script dictated a dialog cycle, prompting each step that had to be performed in the interface of the collaborative environment: first, one partner was asked to propose a correction; then, the other partner was requested to express his approval or disapproval of the proposition. If disapproving he was asked to give an explanation, which the first partner had to concur with in turn. This cycle went on, until they had agreed on a correction. Only then would the system allow them to actually perform the correction in the graphical tool of the interface.

Pfister and Haake (2002; see also Pfister & Mühlpfordt, 2002) have developed a cooperation script structuring the discourse among learners in different knowledge domains in a very similar way as the script by Hron et al. (1997). They call their script a “learning protocol”. In their computer-mediated collaboration setting, the interface would ask participants to choose from a predefined menu of contribution types (e.g. question, explanation) before typing their specific contribution. Also, participants were asked to indicate which previous contribution in the discourse their contribution was relating to. When the message was then added to the dialog history, the chosen contribution type as well as the reference were denoted. Further, the system assigned alternating roles to participants (e.g. tutor), which then again had an impact on the contribution types available to that person. Pfister and colleagues have tested their learning protocol approach in different knowledge domains and with different group sizes.

As a last example for this category of cooperation scripts, we want to cite the script implemented by Baker & Lund (1997) in their C-CHENE collaboration environment. While their cooperation script is similar to the latter two in that it is also implemented in the interface of a text-based computer-mediated collaboration scenario, it differs in the degree of coercion exerted on the collaborators. Two students collaborate on modelling tasks in physics. The interface is split into two parts: a construction area with a graphical tools and a communication area. As part of the communication area, the partners have a set of “communicative act buttons” at their disposal to help them structure their text-based communication. Some of the
buttons relate directly to actions in the construction area. Others offer help with the interaction management (feedback and coordination). A third category of buttons consists of starters for a contribution (like in the approach by Palinscar & Brown), which allow the students to type free text when chosen. All actions are added to a dialog history. It should have become obvious from the description that this cooperation script allows for much more freedom of choice on the students part.

In summarizing, on a continuum of “degree of coercion” (Dillenbourg, 2002), the script by Hron and colleagues (1997) would be situated furthest towards the high coercion end, followed by Pfister & Haake (2002), and Baker & Lund (1997).

1.2.2 Combining Socio-Cognitive Script (Roles and Interactions) and Content-Specific Structuring (Scaffolds)

In the recent years, the research group around Heinz Mandl at the University of Munich, Germany, has conducted a number of studies investigating the effects of cooperation scripts on collaborative learning in small groups at the college level. Their studies are particularly interesting as they distinguish and implement two types of cooperation scripts: interaction-related versus content-related scripts. The two types of scripts aim at supporting different aspects of the collaborative learning process. An interaction-related script prescribes roles and promotes interaction patterns. The script assigns roles and specifies the cognitive activities the student in the respective role should engage in. For example, explainer-role: summarizing, learner-role: asking questions, recapitulating. The kind of support provided by this type of script is similar to examples from traditional collaboration research described above. A content-related script provides scaffolding with regard to the content domain. In other words this type of script supports effective domain specific strategies. For example, when learners are asked to apply newly acquired knowledge to a case problem, the script supports learners in taking account all relevant theoretical concepts and empirical findings. This type of scripts can be implemented by providing the learners with guiding questions.

In the Munich research group these two types of scripts have been implemented in different collaborative learning scenarios and in different ways:

Weinberger and colleagues (see Weinberger, Fischer & Mandl, 2001, 2002, 2003) have tested the two types of script on small groups of three students learning
collaboratively in a text-based computer-mediated scenario. The partners of a triad had individually studied text material on attribution theory in the pre-phase of the study. In the collaborative learning phase they were asked to apply their new knowledge on case problems. In this study, both the content-related and the interaction script were implemented by means of guiding questions presented in the shared workspace of the communication interface.

Reiserer and colleagues (see Reiserer et al., 2002, Ertl, Reiserer & Mandl, 2003) investigated the two types of scripts in a peer teaching scenario using a video-conference system with shared workspace for communication. The collaborating partners were asked to teach each other about theories they had learned during the individual pre-phase of the study (the students had studied different theories – one had learned about theory A, the other about theory B). The content-related script was implemented as a pre-structured text document with eight guiding questions presented in the shared workspace. The interaction-related script was also introduced in the shared workspace. It described the role of the learner and the explainer and defined four steps for the interaction.

1.2.3 Providing General Rules for Collaboration: e.g. Härder

The cooperation script employed by Härder (2003) was supposed to support and structure a discussion between two persons with the goal of exchanging information and coming to a consensus decision on who the guilty suspect was in a given criminal case. The research question was: How does a cooperation script influence collective cognitive processes like the pooling and resampling of information, as well as the activity of drawing inferences during discussion? The script contained four general rules: Rule 1 of the script (“exchange information”) asked the partners to exchange information about the case as completely as possible. Rule 2 (“pool information thoroughly”) advised participants on a structured information sampling in two phases. In phase 1, information was to be collected thoroughly and systematically. Subsequently, in phase 2 the implications of the collected information were to be evaluated, and finally integrated to find a consensus. The separation of the two activities of information sampling and decision-making was supposed to avoid an early evaluation and decision on the basis of an incomplete common knowledge base. (3) With the purpose of fostering the reception and comprehension of
information introduced by the speaker, rule 3 (“recapitulate new information”) asked
the listener to recapitulate and evaluate new information. (4) Rule 4 of the script
(“justify solution”) instructed the partners to seek arguments to justify their joint
problem solution. The rules were handed to participants on paper at the outset of the
collaboration.

1.3 Approaches to Classifying Cooperation Scripts

From the examples provided above, it became obvious that there a great differences
in the way cooperation scripts are realized, in the collaborative scenarios (tasks,
group sizes, communication system) they are applied to, as well as in the rationale
behind their application. Some dimensions along which cooperation scripts may
differ are, for example

- Domain/task specific vs. general
- Related to social aspects (roles, interactions) vs. related to content
- Level of granularity
- Adaptive vs. fixed
- Degree of freedom/choice of the collaborators

With regard to the way, the scripts are introduced and presented, we can distinguish

- Embedded in the collaborative environment (e.g. in the interface) vs.
  provided aside of the collaborative environment (e.g. on paper) vs. modeled
  by an expert (e.g. teacher)
- Step-by-step instruction during collaboration vs. script provided prior to the
collaboration

These dimensions are obviously intertwined. For example, the script provided
by Härdor was domain-specific but not content-specific: the script aimed at fostering
the collaborative discourse but gave no hints regarding the specific contents of the
task. Also, the categories within each dimension are not mutually exclusive
dichotomies but rather constitute a continuum. For example, this was discussed for
the degree of coercion of the cooperation scripts embedded in the interface of a
computer-mediated collaboration setting (Hron et al., 1997; Pfister & Haake, 2002;
Baker & Lund, 1997)
In the literature on cooperation scripts few approaches have been made to try to classify scripts by mapping out their generative features. In the following sections, we describe two such approaches in the realm of computer-supported or computer-mediated collaboration.

1.3.1 Syntax and Semantics of CSCL Scripts: Dillenbourg, 2002

In trying to define which attributes could be used to classify CSCL scripts, Dillenbourg (2002) fleshes out what he calls a “syntax” and a “semantics” of CSCL scripts. For each phase of the collaboration, the cooperation script has to define a number of attributes:

- The task that students have to perform. According to Dillenbourg the task definition must include specifications on input, activity and the expected output. The input for a phase may be material like texts or the output of the preceding phase. Completion criteria for the output may be given by activities that need to get done, by a certain output to be reached or by means of time limits set for a task.
- A group definition has to be given for each phase as the group size and criteria for group formation may vary.
- The distribution of the task among group members. This attribute according to Dillenbourg concerns both the distribution of input (e.g. knowledge or information) and the distribution of activity (division of labor). With regard to the way these two kinds distribution interrelate, he states that “input distribution may induce an activity distribution” (p. 74).
- The mode of interaction may vary across phases. Distant as well as co-present activities may be included in the collaborative interaction guided by a script. While during some phases the partners may have to work synchronously, in other phases they may be instructed to work asynchronously. Also, intra-group interactions may be complemented by inter-group interactions. A further aspect is the degree of integration of task interactions and social interactions.
- Proving support on the timing of collaboration is a central function of cooperation scripts. The challenges of working collaboratively and,
moreover, computer-mediated raise a great need for support both on a global as well as a local level of time management (see Rummel & Spada, accepted)

These five attributes form what Dillenbourg (2002) calls the *syntax* of CSCL scripts. However, he warns that while a syntax can be used to build grammatically correct sentences (or in this context cooperation scripts), such sentences may not always make sense if constructed without paying attention to the semantics. Therefore he adds four dimensions to his classification, which denote the *semantics* of CSCL scripts.

- Behind every cooperation scripts lies a *design rationale*. The scripts are built around hypotheses about what constitutes fruitful collaboration and about how a cooperation script can promote such interactions. Dillenbourg (2002, p. 78) calls the design rationale the “spirit of the script”.

- As we have already seen above, scripts vary in how much freedom and choice of how to interact and when they leave to the collaborating partners. Dillenbourg calls this the *coercion degree* of scripts and distinguishes between: (a) *induced scripts*, where the interfaces implicitly induces certain actions or interaction patterns, (b) *instructed scripts*, where students receive oral or written instruction for every phase, (c) *trained scripts*, where students are trained before applying the script in an actual collaboration, (d) *prompted scripts*, where students are cued by the system to take certain roles, and (e) *follow-me scripts*, where students are lead through phases step-by-step by the script without choices. Obviously these examples are not exhaustive, neither do they constitute selective categories, but rather levels on a continuum of coercion. More generally speaking, the degree of coercion is described to comprise degree of freedom with regard to the choice of team members, the timing, the interactions, and the way a possible tutor may interfere.

- *Appropriation* characterizes the level to which the collaborating partners have adopted the script (as shown by their collaborative behavior). The second level of appropriation is the internalization of the script. Dillenbourg states, that his second level is rarely addressed by cooperation scripts.
Finally, if a script that has shown to be successful in promoting fruitful interactions in one domain the question is whether its success may transfer to other domains. This is the aspects of generalizability.

1.3.2 Cognitive Scripts and Cooperation Scripts: Kollar et al., 2003

Comparing cooperations script as employed in CSCL with the original idea of cognitive scripts by Schank and Abelson (1977), Kollar et al. (2002) extract three similarities: Both include directions for engaging in specific learning activities, and for the sequencing of activities (what, when, by whom). Moreover, a description of different roles is part of both kinds of scripts: cognitive scripts, as they provide separated scripts for the different actors of a situation; cooperation scripts, as they distribute roles among the collaboration partners. Building on this argumentation, Kollar et al. (2002) analyze different cooperation scripts on three dimensions:

- The types of activities imposed by the script.
- The sequencing included in the script.
- The role distribution included in the script.

Further they take into account

- The learning objectives associated with the induced activities.
- The format the scripts are presented in, and
- The locus of representation

2 The Danger of Overscripting

In his talk, Dillenbourg (2002) expressed concern that the idea of scripting collaboration and particularly collaborative learning may lead to consequences “drifting us away from the genuine idea of collaborative learning” (p.64). While research has shown that most often collaboration is not likely to be successful in and by itself (e.g. Cohen, 1994; Dillenbourg, Baker, Blaye & O’Malley, 1995), scripting collaboration on the other hand might prevent the independent, exploratory thinking required for generative learning or problem-solving. The danger is to “overscript” the collaborative interaction (Dillenbourg, 2002). This is especially true for highly coercive scripts which dictate interaction in an inflexible way. Dillenbourg argues
that a high degree of coercion might decrease student motivation. However, he does not provide evidence to support his assumption. In our paper (Rummel & Spada, accepted) we have argued that following the motivation theory of Deci and Ryan (1985), which identifies self-determination as a major constituent of motivation, we would expected that cooperation scripts may cause motivational problems if they regulate the interaction in a strict way. Motivational reactance towards the cooperation scripts might impede the internalization of the script as a standard for subsequent collaborative work. Similar considerations as well as empirical observations pointing in that direction have been made by researchers who have successfully applied scripts to enhance computer-mediated collaboration in their own research (Bruhn, 2000; Hron et al., 1997). Kollar (2001) has presented preliminary results in support of the assumption that script may have motivational drawbacks.

Then, if collaboration cannot be scripted over many sessions the question is, whether the effects of a cooperation script outlast the experimental session in which it was provided by promoting collaborative competences.

3 Cooperation Scripts as an Instructional Support

Our hypothesis is that scripted computer-mediated collaboration can also trigger learning about collaboration: Partners who jointly work on a problem-solving task following a cooperation script are expected to acquire collaborative skills, which improve the collaborative process and outcome also in subsequent tasks. Dillenbourg (2002) has included some initial considerations on this idea in his paper (see p. 81, passage on internalization). The hypothesis of learning to collaborate from scripted collaboration might not be all that new as such. Many of the script approaches applied in traditional collaboration research assumed that learners would little by little internalize the script so that the scaffolding provided by the script could be faded out over time (e.g. Palinsar & Brown, 1984). Yet, the systematic empirical testing of the hypothesis is virgin soil in research on cooperation scripts. Particularly in the context of supporting computer-mediated collaboration, cooperation scripts have so far only been applied and tested as online support during ongoing collaboration.
We have developed an experimental paradigm (see Rummel & Spada, accepted) to test the learning effects arising from scripted collaboration. The paradigm comprises two phases of computer-mediated collaborative problem-solving: one task was solved during the so-called “learning phase”, the second during the “application phase”. In the learning phase, a cooperation script was provided to structure the interaction and to build up collaborative competences, which were then expected to become evident in the process and outcome of a second, unscripted collaboration during the application phase. In an experimental study (see Rummel & Spada, accepted) we compared learning from scripted collaboration to three other conditions – learning from observing a worked-out collaboration example, a condition with unscripted collaboration during the learning phase and a condition without a learning phase (see Table 1).

### Table 1. Experimental design in Rummel & Spada (accepted)

<table>
<thead>
<tr>
<th>Experimental variation</th>
<th>Script condition</th>
<th>Model condition</th>
<th>Unscripted condition</th>
<th>Control condition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Learning phase (case 1)</strong></td>
<td>Learning from scripted computer-mediated collaborative problem-solving</td>
<td>Observational learning from a worked-out example of computer-mediated collaboration</td>
<td>Learning from unscripted computer-mediated collaborative problem-solving</td>
<td>No learning phase</td>
</tr>
<tr>
<td><strong>Application phase (case 2)</strong></td>
<td>Assessment of effects of instruction provided in the learning phase</td>
<td>Computer-mediated collaborative problem-solving in all four conditions</td>
<td>Posttest</td>
<td>Data on collaborative process</td>
</tr>
</tbody>
</table>

### 3.1 The Implementation of the Cooperation Script in the Experimental Study of Rummel & Spada

The collaborative task in our experimental study was the interdisciplinary solution of psychiatric cases with combined psychological and physical pathology. Dyads of advanced medical and psychology students were asked to jointly diagnose the patients described in the cases and to develop a suitable therapy plan making use of
their complementary expertise. The two partners collaborated computer-mediated via a desktop-videoconference including personal text-editors and a shared text-editor.

During the learning phase, the dyads in the script condition were provided with a detailed script prescribing specific phases for their interaction. Table 2 gives an overview of the phases instructed by the script. The cooperation script defines phases with specific activities the partners are instructed to engage in, and whether the partners should work jointly or individually during the phase. It further provides a division of labor and roles and a time frame for each phase. Participants received the script instructions in written format. Instructions in the script were given in the following way: “Please, use the following 7 minutes to ask your partner questions you might have about the case. Make use of each others knowledge to clarify information given to you about the patient in the case description before turning to the diagnosis.”

Table 2. The phases of the cooperation script in Rummel & Spada (accepted)

<table>
<thead>
<tr>
<th>Phase</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>short initial coordination: define objectives of task</td>
</tr>
<tr>
<td>2.</td>
<td>scan case description for potential problems with understanding, formulate questions to the partner</td>
</tr>
<tr>
<td>3.</td>
<td>mutually answer questions, coordination: determine course of action (content, time, roles)</td>
</tr>
<tr>
<td>4.</td>
<td>individually work on diagnosis, take individual notes</td>
</tr>
<tr>
<td>5.</td>
<td>exchange notes, discuss individual ideas</td>
</tr>
<tr>
<td>6.</td>
<td>revise individual solutions and formulate final solution for diagnosis</td>
</tr>
<tr>
<td>7.</td>
<td>copy individual parts of solution (diagnosis) in shared editor, integrate</td>
</tr>
<tr>
<td>8.</td>
<td>formulate goals for the therapy</td>
</tr>
<tr>
<td>9.</td>
<td>individually work on therapy plan (division of labor!), take individual notes</td>
</tr>
<tr>
<td>10.</td>
<td>exchange notes, discuss individual ideas</td>
</tr>
<tr>
<td>11.</td>
<td>revise individual solutions and formulate final solution for therapy</td>
</tr>
<tr>
<td>12.</td>
<td>copy individual parts of solution (therapy) in shared editor, integrate final check of entire joint solution</td>
</tr>
</tbody>
</table>
3.2 Characterizing Our Cooperation Script in the Light of The Two Classification Approaches

3.2.1 The Syntax and Semantics of Scripts Proposed by Dillenbourg (2002)

As obvious from the description of our cooperation script, it included many of the dimensions listed in the syntax of CSCL scripts by Dillenbourg (2002):

The script defines phases with specific tasks/activities for each phase. Completion criteria are the time limits set for each phase. The criterion for group formation (or better team formation since we are talking about dyads) is the complementarity of domain knowledge (psychology vs. medicine). This criterion is, however, not relevant for team formation during the phases of collaborative problem-solving, but only to form the dyads at the outset. The group size varies between phases: the partners are instructed to work either jointly or individually. The distribution of activities across the roles in a phase is prescribed (division of labor). The distribution of input is preset by the complementary expertise in the dyad. In this case, the input distribution induces the activity distribution (Dillenbourg, 2002). For example, the physician can be expected to know more about possible side effects of the current medical treatment of the patient than the psychologist. Consequently, he is going to be the one to explain those to the psychologist. Also, he will have to make sure that the side effects are taken into account when diagnosing the patient. On the other hand, the psychologist has knowledge about psycho-therapeutic treatments. Hence, he is going to be in charge of planning the psychotherapy for the patient. The mode of interaction is synchronous as defined by the collaboration lasting one single desktop videoconference session. However, this does not preclude phases where the partners work individually (see Rummel & Spada, in press). To the contrary, particularly in the given collaboration scenario with relevant knowledge distributed over the partners, time for individual reflection and work is indispensible. As already mentioned, a time frame is prescribed for each phase.

With respect to the semantics (Dillenbourg, 2002):

Our cooperation script does have a high degree of coercion as it gives very precise instructions of who should do what and how much time is available for the activity. Thus it dictates the interaction of the collaborating partners to a great extent. However, compared to the cooperation script by Hron et al. (1997), it is not very
coercive in the sense that the communication interface would enforce the script. As the script is provided in written format outside the collaborative environment, the partners might as well choose to not adhere to its instructions. Indeed it was frequently the case that the experimenter had to intervene and reprove the collaborators to stick to the script. In other words, the first level of appropriation, the adoption of the scripts was a problematic issue. Not so much, because people had problems following the script instructions, but more, because they did not want to follow them. People expressed their dislike for being forced to work the way the script told them to do. The second level of appropriation, the internalization was the focus of our experimental study. As has been stated above, we have developed an experimental paradigm to investigate precisely that question. We have tested the internalization of our cooperation script at different levels: the collaborative process during the application phase (see Table 1), its outcome – the joint solution for case 2 – as well as an individual posttest.

We describe the design rationale behind our cooperation script in some more detail as it is prerequisite to understand the results of our study presented in the next section. Our cooperation script (as well as the worked-out collaboration example) was constructed based on assumptions of what aspects characterize a good collaboration in the given type of scenario. In lack of a comprehensive theory on computer-mediated communication and collaboration we integrated empirical findings from different strands of research and came up with three levels colluding in a good collaboration (see Rummel & Spada, accepted): On a “macro” level, the coordination of the joint work is of great importance (Hermann, Rummel & Spada, 2001; Johnson & Johnson, 1992; Malone & Crowston, 1990). Coordination has to be achieved on several levels: managing time constraints, dividing the task into subtasks, dividing labor between the partners, balancing individual and joint work phases, integrating individual contributions. Particularly in the case of complementary expertise of the partners – as in the scenario at hand – a substantial amount of individual work phases is crucial for a successful collaboration. On a “micro” level, important aspects of a good collaboration concern the communication: the way new content is introduced or asked for, mutual understanding is monitored by giving feedback, and turn-taking is orchestrated; O’Conaill & Whittaker, 1997). Finally, domain-specific aspects of a good collaborative working process and a good
joint solution can be identified (Caspar, 1997). In order to come to a good joint solution, particular topics have to be addressed during the interaction. The way these topics are addressed plays a role: breadth and depth, adequacy with regard to a topic’s relevance for the task solution, correctness of the statements, understanding. Also, collaborative steps towards the task solution need to be taken in a particular order.

### 3.2.2 The Dimensions of Cooperation Scripts Presented by Kollar et al. (2003)

It becomes obvious from applying the syntax and semantics proposed by Dillenbourg (2002) to classify our cooperation script, that they cover some of the dimensions by Kollar et al. (2003): the *types of activities* imposed by the script, the *sequencing* included in the script (which activities should be carried out when by whom), and the *role distribution* included in the script. However, the learning objectives, the format the script is presented as well as the locus of representation still remain to be defined:

In contrast to most other cooperation scripts, the *learning objective* of our script is to promote the acquisition of meta-cognitive rather than cognitive knowledge. Instead of improving the knowledge about the contents of the cases they solve, we aim at improving their knowledge and skills in collaborating by providing them with a script for their first interaction. As mentioned before, the script is *presented* in written format. The representation is *located* outside the collaborative environment. In short, participants are handed a small booklet giving them step by step instructions for each phase.

In summarizing, we can conclude that both, the syntax and semantics proposed by Dillenbourg (2002) as well as the dimensions put forward by Kollar et al. (2003) provide important parts of a frame to classify cooperation scripts. Yet, both classification systems are not exhaustive by themselves.

### 3.3 Conclusions: Can People Learn Computer-Mediated Collaboration by Following a Script?

Scripted problem-solving during the learning phase showed positive effects on the dependent variables assessed (see Table 1): the collaborative process during the application phase, its outcome (the joint solution of case 2) as well as the individual
posttest administered after the application phase (for more details on the results see Rummel & Spada, accepted). This leads to the conclusion that cooperation scripts can trigger learning about collaboration and hence constitute a promising means to provide sustainable support for computer-mediated collaboration. Given an appropriate didactic design of the script, partners who work jointly on a problem-solving task following a cooperation script acquire collaborative skills and knowledge that also improve the collaboration in a subsequent task as well as its outcome. It follows that in future research cooperation scripts should be considered more closely as a promising instructional measure and not only to provide support during an ongoing collaboration as in most previous cases of cooperation scripts used to support computer-mediated collaboration.

To counteract motivational problems which cooperation scripts may cause and which may impede the internalization of the script as a standard for subsequent collaborative work, the collaborating partners should be guided to reflect on the relevant features of the script in order to understand their usefulness. In a second experimental study we currently investigate the role of elaboration support on the impact of the script.

4 References


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theoretical anatomy of group learning (pp. 120-141). New York: Cambridge University Press.


Overall Discussion

1 Discussion of Results

In sum, both instructional methods that were developed and empirically tested have shown the capability to improve collaboration in the given scenario. Dyads who received instruction by observing the worked-out collaboration example during the learning phase (model condition) as well as dyads who were led through the collaboration in the learning phase step-by-step by a cooperation script (script condition), outperformed their counterparts in the unscripted and the control condition on many of the dependent variables assessed during the application phase.

Firstly, they produced better joint solutions: in the model condition, better diagnosis and therapy plan; in the script condition, only a better the therapy plan, which did, however, surpass even the model condition’s. The reported motivational problems of the dyads in the script condition at the beginning of their second collaboration cannot be confirmed by quantitative data as motivation was not assessed formally in this study. However, examples of the participants’ frustration with the script they had to adhere to in the learning phase can be found in the transcripts of their collaboration in the application phase. Table 1 gives an example from the dialog of dyad 4.¹

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1 For the collaborative solution of case 2 during the application phase, 2 hours were allocated in total.
2 Translated by author.
The negative motivational effects of the rather coercive script that became evident in the initial phase of the second collaboration and is reflected in the poor performance of this condition on the diagnosis, can be interpreted as a sign of overscripting as discussed in paper four (Rummel & Spada, 2003). The fact that dyads in the script condition still produced the best therapy plans supports the conclusion drawn in the papers and particularly in the fourth one: cooperation scripts constitute a promising means to provide potentially long-lasting support for computer-mediated collaboration by promoting relevant collaborative skills and knowledge. Yet, something has to be done to avoid motivational problems arising from the scripting during the learning phase. Guiding the collaborating partners to reflect on the relevant features of the script was suggested as one possible measure.

Participants in the two instructional conditions further showed better performance on both subscales of the individual posttest: subscale A, asking for knowledge on what makes a good collaboration in the given type of scenario at a more general level, and subscale B, asking participants to describe elements of a good therapy plan.

The results for the analyses of the collaborative process during the application phase are less clear. Particularly with regard to the dialog analysis methodological issues have to be considered, as already discussed in the third paper (Rummel & Spada, in press). Some of these points are raised again below.

The analysis of the activity patterns gained from log-file data proved to be a simple, yet efficient method to gain access to some aspects of the collaborative process, such as the amount of individual and joint work or the number and average length of work phases. It should be emphasized once more that this type of analysis was very feasible compared to the high expenditure required for the dialog analyses. For the present study the analysis revealed that dyads in the model and script condition adhered to the proportions of individual and joint work shown to them during the learning phase. They showed a substantial amount of individual work, which proved to be an important predictor of their performance on the joint solution. A similar result was already found by Hermann, Rummel & Spada (2001).

As discussed in the third paper (Rummel & Spada, in press), in evaluating the analysis of dialog at the macro-level, it is important to note that these scores were gained through a time-sampling procedure: each minute of dialog was classified for
the occurrence of the macro categories. In other words, what was being assessed was the quantity – or intensity – of dialog activity with regard to these aspects. However, the relation of quantity of coordinative dialog activity and quality of the collaborative work is complicated. While coordinative dialog is necessary to structure the collaboration in an optimal way, particularly when working jointly for the first time, counting the minutes of this type of dialog does not tell too much about the quality of the coordination. In the time-sampling procedure employed, two minutes of successful coordinative dialog were counted in the same way as a miscarried coordinative dialog of the same length. In the light of this criticism it would be desirable to complement the quantitative measure by assessing the quality of the coordinative dialog in a more direct way.

Along the same lines, counting the occurrence of utterances on the micro level as in the present analysis, does not give clear evidence about the quality of these utterances. The system of criteria for the micro level was developed to serve as an assessment tool that is not domain specific, but “content-free”. In order to assess the characteristics of the communication, a more qualitative, content-related approach of analysis may be better suited.

The assessment methods that were developed to analyze the collaborative process should be complemented by a qualitative content analysis allowing evaluation of the dialog quality more directly. A promising step in that direction has been taken by a qualitative content analysis of the dialog that was performed as part of a student’s diploma thesis (Sosa y Fink, 2003, see Rummel & Spada, in press). First, a thorough literature review was conducted to identify aspects relevant for a successful collaboration. Further, the transcripts of four collaborative dialogs were examined in an extensive analytic procedure following the methodology of Mayring (2003). From these analyses, seven dimensions were identified to be constitutive for a good collaboration. Subsequently, the dimensions were applied as a frame of analysis to the remaining 5 dyads in the unscripted condition and the entire 9 dyads in the control condition with promising results: a substantial correlation between these dimensions and the quality of the joint solution of these 14 dyads was found (r=0.62; Sosa y Fink, Spada & Rummel, in preparation).
In conclusion, despite the criticisms of the study discussed above, its achievements should not be dismissed. The empirical study did reveal some substantial effects of the instruction provided in model and script conditions on the dependent measures: collaborative outcome (quality of the joint solution), individual knowledge (posttest), and collaborative process (amount of individual work). Furthermore, the study did provide some evidence for the correlation between process and outcome (comparison of successful vs. less successful dyads for amount of individual work, and correlation reported for the seven dimensions of the qualitative content analysis). These results were found despite the small sample size, and despite the fact that many studies investigating the effects of support measures in computer-mediated collaboration settings could not detect effects on outcome measures and were even less likely to find correlations between the collaborative process and the outcome.

2 Additional Theoretical Aspects

In this section, some theoretical aspects are discussed that are of relevance for the present dissertation and were not included in the four papers or were included only in an abbreviated manner due to page restrictions.

2.1 Collaboration on the Basis of Divergent Knowledge Backgrounds

The present scenario operates on dyads with complementary knowledge background, in other words, two people who bring divergent knowledge to the task. Thus some theoretical models of information processing in groups are of relevance, particularly research on information pooling in groups (Stasser & Titus, 1985, 1987; Wittenbaum & Stasser, 1996) and grounding in communication (Clark & Brennan, 1991). These approaches have already been mentioned briefly in the first and the second papers (Rummel & Spada, accepted; Rummel & Spada, in press). Here each of them will be discussed more broadly, introducing the main features of the theory and pointing out its relevance for the research that was part of this dissertation. Further, the theory of groups as transactive memory systems (Hollingshead, 1998; Moreland, 1999; Wegner, 1987) is of interest for the present research and will be introduced briefly.
2.1.1 Information Pooling in Groups

Problem-solving and learning in collaborative settings have shown to depend on two components: (1) the mutual transmission and pooling of knowledge, and (2) the joint elaboration of knowledge (Kneser, Fehse & Hermann, 2000). Given that the previous knowledge of the partners is sufficiently divergent (unshared), the collaborative setting offers an excellent opportunity to learn from one another. While the collaborating partners expound their opinions to each other, they exchange knowledge. Furthermore, the necessity to make it explicit leads to constant elaboration of the knowledge during interaction. Roschelle and Teasley (1995) have described the processes of learning during collaboration as a cycle of “convergent conceptual change”: the partners exchange ideas, evaluate them in discourse, make corrections, and finally establish convergence.

A well-studied problem in the context of collaborative problem-solving and decision-making is the pooling of shared information (common to all members of the group) as well as unshared information (accessible only to individual members of the group). Research has shown that groups often tend to focus their discussion on the already shared portion of the knowledge, while neglecting those parts uniquely held by members of the group (Larson, Christensen, Franz & Abbott, 1998; Stasser & Titus, 1985, 1987; Wittenbaum & Stasser, 1996). Thereby groups often miss the opportunity to make a more informed decision than would be possible for the individual member. The failure of collaborating partners to pool their unshared knowledge resources is even more detrimental given a situation where the individual group members are mutually dependent on each others knowledge in order to be able to successfully complete the group task (Johnson & Johnson, 1992).

Such a situation is, for example, given in the case of a so-called hidden profile (Stasser, 1988, 1992; Stasser & Stewart, 1992). The rationale behind a hidden profile is to distribute pieces of information critical for solving the group task in an experimentally controlled form between the collaborating partners: every participant gets a different subset of unshared information in addition to the shared information. Due to this distribution of information, the solution is not obvious (hidden) for the individual group members at the beginning of the discussion. In order to find the correct solution, the participants need to pool and consider the critical information during discussion. Consequently, finding the correct solution can be understood as an
indicator of successful information pooling. The hidden profile paradigm has mostly been employed to study information pooling in decision-making groups that operate on a limited set of items, e.g. finding the guilty suspect in a murder mystery where different evidence points to the different suspects (Stasser & Stewart, 1992) or coming to a joint decision for one among several candidates for an open job position (Schulz-Hardt, Frey, Lüthgens & Moscovici, 2000). Such situations allow for a precise experimental distribution of items between group members as the information available for the task solution is limited to the experimentally invented pieces of information. The prior knowledge of the participants does not play a significant role – personal beliefs may, however, still come to bear in the way certain information is evaluated by individual group members. For example, in the murder mystery, incriminating evidence for a female suspect may be evaluated differently than similar evidence for a male suspect who is additionally characterized as an unpleasant type of person.

Recently, Härder (2003) has extended the information pooling paradigm to computer-mediated problem-solving of dyads communicating via a desktop-videoconference. Working with a revised and adjusted version of the murder mystery paradigm (Stasser & Stewart, 1992), Härder was not only able to replicate the information pooling effect in this setting, but further found effects of structuring the interaction with a cooperation script and of providing a shared application to support the information pooling and problem-solving process.

Further, Thalemann (2003) scrutinized the relevance of shared knowledge on the collaborative problem-solving performance in a text-based computer-mediated scenario. On the basis of an experimentally well-controlled distribution of shared and unshared knowledge items (knowledge of: operators, initial states, goals), two people were asked to jointly develop a concept for an online-shop. One partner took the customer role (salesman of a sport company), the other the role of an IT-consultant. In sum, shared knowledge showed positive effects on the group performance. Shared knowledge about initial states and goals did have a greater effect than knowledge about operators. Thalemann had further expected effects of the shared knowledge on the coordination and communication during the computer-mediated collaboration; shared knowledge should facilitate grounding processes and information exchange.
However, no such effects were detected. Thalemann suspected that the amount of shared knowledge may have been insufficient to reveal such effects.

In the scenario investigated in this dissertation a situation comparable to a hidden profile existed with the *complementary expertise* of the psychologist and the medical doctor. The two patient cases utilized in the study were designed specifically to require both medical and psychological expertise: in both cases a psychological disorder (e.g. depression) coincided with some physical illness (e.g. multiple sclerosis). A correct diagnosis and therapy plan for the patients could only be deducted if the collaborators exchanged relevant domain knowledge. For example, the psychologist needed to get information on the side effects of the patient’s current medication to be able to evaluate the psychological symptoms correctly. Further, symptoms coming along with the physical illness (e.g. concentration problems) made particular therapeutic treatments unsuitable (e.g. cognitive behavior therapy).

However, the present setting also differs from a hidden profile in important ways, because an experimentally controlled distribution of critical information was not fully realized. In addition to the case description, which both partners received (shared information), they were provided with texts on domain knowledge relevant for the specific case (unshared information). The text material was different for the psychologist (e.g. excerpts of the ICD-10) and the medical doctor (e.g. a text on side-effects of certain medical drugs). This distribution of relevant information was intended to increase the complementarity of knowledge already existing between the collaborators. However, the domain knowledge the partners brought with them could not be fully controlled as they were “natural” experts. The attempt was made to control this natural expertise to some extent by assessing participants’ prior domain knowledge in the questionnaire sent to them prior to their participation. In the questionnaire they were asked to list the courses they had attended, which allowed assessment of their level of relevant domain knowledge at least indirectly, as the contents of the courses were known. Assessing relevant domain knowledge more directly in a pretest would not have been sensible as the questions might have triggered participants to the relevant concepts.

While the distribution of knowledge may not have been as experimentally controlled as in the situations investigated by Stasser and colleagues, the pooling of relevant unshared knowledge was also one of the central requirements during
collaboration. And, as the information pooling effect cited above (Stasser & Titus, 1985, 1987; Wittenbaum & Stasser, 1996) has revealed, it was a process that required support. Meta-knowledge about one’s own expert status and mutual recognition of expertise, as well as explicit assignment of expert roles at the onset of the collaboration have shown beneficial effects on the pooling of unshared information and consequently, on the quality of the results of the collaboration (Stasser, Stewart & Wittenbaum, 1995; Stewart & Stasser, 1995). In the experimental study presented here, meta-knowledge of expert status was induced in the initial instruction. Further, together with their set of text material both participants were provided a list including their own texts as well as the texts handed to their partner (see Appendix A), which were intended to increase their awareness of the distribution of relevant information.

A second feature in the present experiment that supported the information pooling process was the shared text editor. The possibility to represent information externally in a way that made it available to both partners simultaneously was expected to have positive effects on the pooling of information (Härder, 2003) and the visualization of a shared problem space (Roschelle & Teasley, 1995). According to Suthers (2001, p. 2) shared workspaces can “mediate collaborative learning interactions by providing learners with the means to express their emergent knowledge in a persistent medium, where the knowledge then becomes part of the shared context”. The shared workspace serves as an external memory for the collaborative problem-solving process, and facilitates the construction of a joint work product.

2.1.2 Grounding in Communication

While the pooling of unshared information is one challenge, the establishment and maintenance of shared knowledge based on mutual understanding is a further challenge during collaboration and once more has particular relevance in interdisciplinary collaboration. This phenomenon is widely known as “grounding” in communication (Clark & Brennan, 1991; Baker, Hansen, Joinier & Traum, 1999). Successful communication presupposes that the partners understand each other. This is by no means trivial. Understanding each other not only requires being able to speak and understand the same language in a literal sense, but also in a figurative
sense. When collaboration partners come from different cultural or disciplinary backgrounds, instantiating and sustaining a common language and convergence on central concepts is particularly difficult. The process of establishing “common ground” (Clark & Brennan, 1991) includes the clash of different mindsets. In interdisciplinary collaboration this comprises different theoretical concepts, methodological approaches, and cultures of thinking. Many times interdisciplinary collaboration is burdened by naïve theories and attitudes about the partner’s domain. On this background, the achievement of common ground requires constant monitoring and explicit feedback. Additionally, “grounding” in collaboration includes not only the establishment of a “grounded” use of language and concepts, but also the negotiation of a shared understanding of the task and the joint goals, as well as agreement on the operations necessary to achieve those goals. It is important to note that grounding also requires the development of a meta-knowledge – a shared awareness of what can be regarded as common ground (shared language, knowledge, goals etc.).

In the present study, the collaborators were supported in their grounding process through the instruction provided by model and script. As apparent from the description of the exemplary collaboration that was the basis for both model and script (Figure 1; see also Rummel & Spada, accepted), phases 1-3 aimed particularly at establishing common ground at different levels: in phase 1 the participants were supposed to achieve common ground on the task and their joint goals; the focus of phase 2 (individual) and 3 (joint) was on grounding processes with regard to the case, specifically the use of domain-specific language and concepts; phase 3 further aimed at achieving common ground with regard to the course of action.

**Figure 1. Phases 1-3 from the exemplary collaboration as described in Rummel & Spada (accepted)**

<table>
<thead>
<tr>
<th>Phase</th>
<th>Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>short initial coordination: define objectives of task</td>
</tr>
<tr>
<td>2.</td>
<td>scan case description for potential problems with understanding, formulate questions to the partner</td>
</tr>
<tr>
<td>3.</td>
<td>mutually answer questions, coordination: determine course of action (content, time, roles)</td>
</tr>
</tbody>
</table>

The following table (Table 2) shows the instruction for these three phases in the script condition. In the model condition, the same phases were implemented in the presentation (recorded dialog). The two model collaborators depicted in the
presentation briefly talk about their task. Then, the psychologist asks a question about a medical examination that was carried out in connection with the patient’s heart disease. While answering this question, they realize that it would be a good idea to go back to the case description individually, scan it for potential problems with understanding, and formulate questions to the partner. Then, they come back together and try to mutually answer those questions. Finally, they coordinate their further course of action.

Table 2. Instruction for phases 1-3 in the script

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Briefly (3 minutes) discuss the collaborative task with your partner: What is your task? What are you supposed to do together?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 2</td>
<td>Scan the case description for potential problems with understanding. Mark aspects (1) that you would like to ask your partner about (2) that you would like to explain to your partner from the perspective of your domain</td>
</tr>
<tr>
<td></td>
<td>This phase should take about 7 minutes.</td>
</tr>
<tr>
<td>Phase 3</td>
<td>Mutually answer questions about the case (e.g. unknown technical terms). Make sure to → give explanations your partner can understand → demand further explanation if necessary → give your partner feedback of your understanding</td>
</tr>
<tr>
<td></td>
<td>The goal of this phase is to develop a shared understanding of the present case. You have 10 minutes for this phase.</td>
</tr>
</tbody>
</table>

While the first three phases of both model and script focus particularly on processes of grounding at the different level described, instances of grounding support have been woven into the instruction over the entire learning phase. In the model presentation, the two collaborators frequently engage in the negotiation of meaning of domain-specific concepts and terminology. Furthermore, at several points in the course of their collaboration, they come back to the definition of their joint task, discuss and redefine sub-goals. Analogously, in the script condition, the collaborating partners are reminded to pay attention to giving explanations their partner can understand, to demand further explanation if necessary, and to give their partner feedback of their own understanding at the beginning of each joint work phase (same instruction as given in phase 3; see Table 2). Also, they are instructed at

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1 Translated by author.
several points in the course of their collaboration to briefly reconsider their joint task and redefine sub-goals if necessary.

In the evaluation of the collaborative processes, aspects of grounding were assessed in the dialog analysis at the micro level as well as in the “mutual understanding” category in the domain-related analysis of dialog contents (see Rummel & Spada, in press).

The linguistic copresence heuristic (Clark & Marshall, 1981) explains how language, concepts and knowledge become part of the common ground through their mentioning in the conversation. In addition, the physical copresence heuristic assumes that everything that is part of a shared environment can be regarded as common ground. This heuristic is relevant for the present scenario in the sense that the shared text editor is a shared environment. Similar to what was stated in the previous section about the role of the shared text editor for the pooling of information, it can be an important aid for the grounding process (Clark & Brennan, 1991), particularly in synchronous computer-mediated collaborations (Dillenbourg, Traum, & Schneider, 1996). Apart from the shared text editor which may facilitate the establishment of common ground, the characteristics of the remote communication via desktop videoconference can, however, be expected to raise the grounding costs in the present scenario (Baltes, Dickson, Sherman, Bauer & LaGanke, 2002).

2.1.3 Groups as Transactive Memory Systems

The theory of a transactive memory (Wegner, 1987; for more recent work see: Hollingshead, 1998; Moreland, 1999) describes group memory as a system consisting of the individual memory systems of its members and their interconnections. Wegner (1987) noted that people often take advantage of each other’s memory as external storage aid. As the individual memory systems store different knowledge and the group members each take responsibility for their particular “expert” knowledge, the group memory has a greater capacity than the individual memory systems. However, the transactive memory system is in need of a shared awareness of who knows what to manage the distribution of expertise among the group members. According to Wegner (1987) two pieces of information have to be filed with each knowledge item during transactive encoding: a cue denoting the
item in an unambiguous way for later retrieval from the transactive knowledge base and further, an information allocation filed together with the item pointing to the locus of its storage; in other words, to the person of whose expert knowledge the item is a part.

In research on collaborative problem-solving the advantages of using the group as an external memory store have revealed positive effects on group performance (Liang, Moreland & Argote, 1995; Moreland, Argote & Krishnan, 1996). Particularly, when the group task required a high amount of coordination because of (a) the distribution of relevant information between the collaboration partners, (b) task complexity, or if (c), the collaborating partners were distributed over different locations and the communication was technologically mediated. All three criteria apply simultaneously to the scenario investigated in this dissertation. Thus, the development of a transactive memory system taking advantage of the expertise distributed among the collaborating partners would have been desirable.

The following two sections illustrate what was done in the present study to set the stage for the development of a transactive memory in the application phase. During the learning phase, model and script supported the collaborating partners in grounding processes pertaining to their interdisciplinarity; particularly, phases 2 and 3 of the collaboration were dedicated to securing mutual understanding as well as the awareness of knowledge differences. Further, the earlier section on information sampling described that meta-knowledge of expert status was induced in the instruction, and that participants were provided a list showing the different materials they had received to further increase their awareness of the distribution of relevant information. Both can be regarded as prerequisites for the development of a transactive memory.

Assessing the establishment of transactive memory was not a central goal of the present process analysis. Yet, some data can be presented from the collaboration during the application phase that illustrates how dyads explicitly acknowledged their distributed expertise and indicated what might be called a transactive memory system. In several dyads, instances of an awareness of mutual expertise were obvious from acknowledgements of the partner’s and one’s own expertise in the dialog. In the example given in Table 3, the student of psychology expresses the expectation that
the patient’s medication would be part of the expertise of his medical partner, while he could contribute on the psychological therapy.

| Table 3. Dialog of dyad 5 during collaboration in the application phase (minute 46, seconds 17 through 32)1 |
|---|---|
| Psych | SSRI are medications, right?20(1) |
| Med | Yes? |
| Psych | Mhm, these selective serotonin reuptake inhibitors.24 |
| Med | Do you also have something on the medication?26 |
| Psych | Ah, okay.25 |
| Med | No, no, no, ["that’s your area."27] |
| Psych | [Yes, acute therapy] affective, hm?28 |
| Psych | (2) I have, I only have the psychological therapies here.22 |

To conclude, what all three theoretical conceptualizations (the information sampling model, the concept of common ground, and the theory of transactive memory) have in common is the assumption that successful group functioning depends on the interplay and balance between shared and unshared knowledge. Furthermore, all three approaches describe the necessity of a meta-knowledge – a shared awareness of the distribution of knowledge and expertise within the group. The latter two theories call for such meta-knowledge directly. The information pooling model originally assumes that knowledge is “shared” whenever it is available to all group members. However, meta-knowledge about one’s own expert status and explicit assignment of expert roles at the onset of the collaboration were shown to have beneficial effects on the pooling of unshared information and consequently, on the quality of the results of the collaboration (Stasser, Stewart & Wittenbaum, 1995). Thus, it can be argued that this model has also shown the necessity of a shared awareness of who knows what.

The aspect of balancing shared and unshared knowledge is related to another important characteristic of collaborative problem-solving: the interplay of phases of individual and joint work. Individual work phases are crucial to allow each group member to pull back to consider aspects of the problem from the perspective of his or her expert domain. Joint work phases are necessary to share information and to update the meta-knowledge about the distribution of expertise in the group.

1 Translated by author.
2.2 **Collaboration of Psychologists and Medical Doctors: Towards the Development of a Curriculum Element**

As mentioned before, the collaboration of psychologists and medical doctors on complicated cases is a daily challenge in German psychiatric hospitals. Yet, both parties seem to be insufficiently prepared to meet this challenge: they seem to lack in general collaborative skills (micro and macro level) and in competences for interdisciplinary dialog so that these collaborations are often experienced as frustrating and unsuccessful (Tönnies, Breuer-Schneider & Schwieger, 1992). Results from this research may be used to develop curriculum elements fostering understanding of and skills for successful interdisciplinary collaboration in the medical and the psychological curricula. Here the *Problem-Based Learning* (PBL) paradigm could provide a helpful frame; its learning goals and assumptions bear resemblance to the expectations formulated for the learning in the present collaborative scenario.

Problem-Based Learning is a curricular design approach with the goal to shift the focus of university education from lectures and other faculty-centered forms of instruction where knowledge is delivered by one teacher to many students, to self-directed problem-solving and learning in small groups of four to nine students. The concept was developed in the 1960s to improve the medical program at McMaster University in Canada. Stimulated by the McMaster approach, other newly created medical schools (Maastricht in the Netherlands and Newcastle in Australia) developed PBL curricula in the early 70s. This was followed in the 1980s by some existing medical schools that began converting their entire curricula to Problem-Based Learning (headed by the University of Hawaii, the University of Harvard, and the University of Sherbrooke in Canada). Subsequently, the Problem-Based Learning paradigm has been adopted by medical schools around the world (Boud & Felletti, 1991). Over the past decades it was adopted in a variety of professional schools (nursing, law, business, engineering, psychology), college level courses in the sciences and humanities, as well as primary and secondary schools (for an overview, see Zumbach, 2003). Barrows and colleagues of South Illinois University have documented their application of the Problem-Based Learning approach in an outstanding way and have published seminal articles (Barrows & Tamblyn, 1980; Barrows, 1985, 1986, 2000). Barrows (1986) provided a taxonomy systematizing the
Overall Discussion

various ways the concept of Problem-Based Learning was realized. One main difference among the approaches is the extent to which the learners engage in self-directed problem-solving activities. In many approaches presentation of a problem case (many times together with its solution) is just an add-on to the regular lecture-based instruction. Only very few approaches realize the Problem-Based Learning concept by reorganizing the entire curriculum.

At the heart of the Problem-Based Learning process is the “problem”. It serves as a starting point and a springboard for learning. In the original domain, medicine, problems are authentic clinical cases that are presented to the learners. They can be presented either in a purely paper-based format, with additional illustrative material, as video recording, or even in the form of a computer simulation. Computer-based learning systems like CAMPUS (Riedel, Singer, Heid & Leven, 2000; Riedel et al., 2001; see Figure 2) present the patient cases in an interactive multimedia format including various sources of information (a file with the patient’s medical history, interviews of the patient, his spouse or parents, x-rays, laboratory findings, background readings) that the learners may look at. The learner can further perform examinations and get results on those.

Figure 2. Screenshot from the CAMPUS learning platform (http://campus.fh-heilbronn.de/)
Within the philosophy of the Problem-Based Learning approach, the goal is to purposefully design a series of problems that build on one another and thus form an entire curriculum. A central mechanism of the learning process is learning transfer from one case to the next. The theoretical foundations of this mechanism can be described within the research on Case-Based Reasoning (Kolodner, 1993, 1997; Riesbeck & Schank, 1989). The central idea of this paradigm is that during problem-solving the learners retrieve former cases and their solutions from memory. Then, they adjust these solutions to the case problem at hand. According to Kolodner (1997) Case-based Reasoning operates to a great extent on “analogical reasoning”: old and new problems are compared and the applicability of old solution features is assessed. On the basis of this evaluation the new problem is solved in analogy to the old – after necessary adjustments have been made. Experience with the new problem and its solution add to the “case library” and become available for retrieval and application to new problems. The case library is continuously reorganized on the basis of experiences with new problems: cases are indexed with respect to the situations for which they are valid; in a second step, generalizations are made from cases that apply to situations that are equivalent, indicated by their index.

The comparison with Case-based Reasoning has illustrated one important premise of Problem-Based Learning: it is assumed that learning should always build on the prior knowledge and experiences of the learner.

The main goal of Problem-Based Learning in medicine (Barrows, 1986) is to involve the students in constructive knowledge-building activities while solving authentic problems. The problem-solving activities can be expected to support the process of knowledge encapsulation (Schmidt & Boshuizen, 1992), while avoiding the danger of knowledge compartmentalization (Renkl, 1996). Contextualized knowledge, readily available for application to clinical cases should result from the Problem-Based Learning curriculum. In addition to the acquisition of domain knowledge, learners are expected to develop procedural knowledge of the clinical reasoning process (Barrows, 1986). Furthermore, the self-directed problem-solving process within the group should foster their ability to learn and work in a self-directed manner. Finally, motivational benefits are expected to arise from the Problem-Based Learning format more so than from traditional faculty-centered instruction where students are most often assigned the role of a passive audience.
Schmidt (1983) describes a seven-step implementation of Problem-Based Learning:

- **Step 1: Clarifying terms.** Recognizing terms that lack clarity. Asking for or giving explanations.
- **Step 2: Defining the problem.** Defining the issues captured by the problem.
- **Step 3: Analyzing the problem.** Brainstorming associative connections to the problem. Activating previous knowledge within the group. Listing relevant aspects and questions. Providing as many explanations, alternatives and/or hypotheses as possible for the problem.
- **Step 4: Systematic clarification.** Creating links between listed aspects and explanations. Classifying themes that emerged at the brainstorming session into higher order groupings.
- **Step 5: Formulating learning objectives.** On the basis of knowledge that is lacking, formulating learning goals in unambiguous, well-defined and concrete terms.
- **Step 6: Self study.** Establishing keywords. Checking sources. Synthesizing relevant material.
- **Step 7: Reporting.** Sharing with other group members the results of one's inquiry.

In connection with the rapidly evolving technological solutions for computer-mediated communication, attempts have been made to implement Problem-Based Learning in distributed collaboration settings (Cameron, Barrows & Crooks, 1999; Steinkuehler, Derry, Woods & Hmelo-Silver, 2002). In such settings promising new opportunities arise, e.g. for making materials and resources available (see CAMPUS platform described above) as well as for scaffolding the collaborative process and providing individually tailored learner support.

The Problem-Based Learning approach shares similarities to the goals that have been formulated for the collaborative problem-solving process in the scenario utilized in the dissertation.

One important similarity is the expected learning transfer between problems. A related aspect is the emphasis on the acquisition of procedural skills in addition to contextualized domain knowledge: in the present scenario the focus is on the
promotion of collaborative process skills and clinical reasoning; in medical Problem-Based Learning, developing clinical reasoning and self-directed learning skills are central (see Barrows, 1986). In the present scenario, learning transfer was expected particularly with regard to these procedural skills; as has been described earlier (see Rummel & Spada, accepted), no content-related transfer was possible between the two cases. A further characteristic feature of the collaborative problem-solving process in the present scenario was the emphasis on an alternation of phases of joint work and phases of individual work, which is equally present in the seven step implementation of Problem-Based Learning described above.

Building on these similarities, a curriculum element could be developed with the goal to help psychologists and medical doctors to learn to collaborate better. In accordance with the Problem-Based Learning approach, the curriculum element could include a series of problems (cases) that have to be solved collaboratively by dyads comprising one person from each domain: a student of psychology and a student of medicine or a psychologist and a medical doctor – if the instruction was to be implemented in a professional training course. A common feature of the problems would be that they require medical as well as psychological expertise. The problem-solving within the dyads would be realized as distributed, computer-mediated collaboration. For one, the collaboration should be realized in a remote setting as the students come from different departments of the university, which are often locally distributed over town. Collaboration thus becomes more feasible when making use of computer-mediated technology. Furthermore, remote collaboration with a colleague from the other domain is what most psychologists and medical doctors will have to rely on in their professional every-day life. Getting some experience working with such computer-mediated collaboration systems would thus be desirable also from a practical perspective. The problem-solving process of the dyads should follow the exemplary collaboration pattern described (see Rummel & Spada, accepted, Figure 1) involving an alternation of phases of joint and individual work. The collaboration could initially be guided by a script like the one implemented in the present study. In the course of the curriculum, the scripting would be faded out, giving way to independent problem-solving. Presumably this transition would not happen abruptly from one problem to the next as in the present study, but in a supported procedure
similar to the transition from studying worked-out examples to solving problems described by Renkl, Atkinson, Maier and Staley (2002).

The remote dyadic problem-solving could be complemented by face-to-face meetings of all dyads (with a maximum of 10 dyads, 20 participants). In an initial plenary session worked-out model scenes of an interdisciplinary collaboration between a medical doctor and a psychologist could be presented to illustrate the importance of establishing competences for such collaboration (see Schornstein, 2003). In part, the scenes could show failure of collaborative efforts; other scenes could demonstrate successful collaboration. The goal of a subsequent plenary session could be to share experiences among dyads. Dyads could be coupled in teams and given instructional support for mutually reflecting on their collaborative solution processes from recordings.

The curriculum element sketched above combines aspects of Problem-Based Learning with our instructional measures of modeling and scripting. Furthermore, intertwining dyadic and individual problem-solving phases with plenary sessions that allow dyads to profit from each other is one of the particular strengths of the proposed curriculum element.

3 Conclusions for Further Research

As described in the papers included in this dissertation (e.g. Rummel & Spada, accepted), the model and the script were carefully designed to include the same contents in their instruction. The two conditions did, however, differ in some ways. For one, the manner in which instruction was delivered (via model or script) was confounded with the possibility for participants to practice collaborating via the videoconference and with their partner. In the script condition participants collaborated for the entire 2 hours – although the steps/ phases of their collaborative work were predetermined by the script. In the model condition participants mainly remained passive and only collaborated with their partner during a few reflective phases. On the basis of findings from research on individual learning with worked-out examples (Stark, 1999; Stark, Gruber, Renkl & Mandl, 2000), we assume that a well-balanced mixture of observing solution steps and active problem-solving would
yield the best results. To optimize observational learning from the model, short
phases of active collaborative problem-solving should be included in future studies.

Secondly, the script and model condition differed in the extent to which they
triggered active elaboration and reflection on the instruction. In the model condition
the elaboration of the worked-out collaboration example was promoted by eliciting
self-explanations and by providing instructional explanations before and after each
scene (see Rummel & Spada, accepted). Self-explanations (Renkl, Stark, Gruber &
Mandl, 1998) and instructional explanations (Renkl, 2002) have shown to affect
the processing of worked-out examples. In a recent study, Schworm and Renkl
(submitted) have shown the effects of different types of self-explanation prompts on
the acquisition of complex cognitive skills (argumentation) from video-based models.

In contrast, in the script condition participants were too wrapped up in
collaborating to reflect on the importance of the specific steps of collaboration
instructed by the script. Without reflecting on the various elements of the script,
however, the collaborating partners may fail to fully understand their relevance. This
may in turn hinder the internalization of elements of the script and thereby their
acquisition as a standard of subsequent collaborative work. In future research, the
script condition should therefore include reflection on the features of the script in a
similar way as in the model condition. In a current study within the DFG-project, the
issue of elaboration support is being addressed: the effects of a model and a script
with elaboration support and without such support are compared to investigate the
importance of guiding meta-reflection about the instructional support measures.

In the study presented in this dissertation, the effects of the instructional
measures were tested in only one application case. Therefore long-term effects of
script or model can only be claimed with care. It would be desirable to have data on
at least one more, delayed application case in order to support the conclusion that the
invented instructional measures (model and script) have the potential to improve
collaborations with long-lasting effects. One possibility to gain such data might be to
run the study as part of a curriculum element in collaboration between psychology
and medicine as sketched above. The acquisition of competences in computer-
mediated interdisciplinary collaboration might be a benefit worth achieving for
students in both domains in addition to content-related knowledge acquisition.
At several points in the papers expectations were expressed that the results should hold true for scenarios with the same generic features as the present one, where the challenge of solving a complex task collaboratively, moreover, based on complementary domain knowledge of the collaborating partners, merges with the challenges of communication in a computer-mediated setting. This conclusion requires further testing. It would be interesting to investigate to what extent the learning gains found from the instructional measures (model and script), transfer to other computer-mediated remote collaboration scenarios, particularly different domains and different communication settings (e.g. text-based, asynchronous). One possible test scenario could be the collaborative computer-mediated solving of complicated legal cases by law students in collaboration with business students.

If would further be desirable to investigate applicability of the assessment methods developed to analyze the collaborative processes of the application phase to other computer-mediated collaborations, as formulated in the third paper (Rummel & Spada, in press).

4 References


Appendix A: Lists Provided with Materials

1 List Provided with Materials “Herr Z.”

Bitte lese die Fallbeschreibung sorgfältig durch und unterstreiche wichtige Informationen. Weiterhin stehen Dir Lehrbuchtexte zur Verfügung. Verschaffe Dir bitte in der vorgegebenen Zeit einen groben Überblick, welche Texte Dir zur Verfügung stehen und welche Themen sie behandeln (wenn Du willst, kannst Du Dir Notizen machen oder etwas unterstreichen). Die Zeit reicht nicht, um die Texte ausführlich zu lesen! Dazu wirst du später noch an bestimmten Stellen der Kooperation Gelegenheit haben.

Dem Medizinstudenten/ der Medizinstudentin liegen folgende Materialien vor:
- Fallbeispiel Herr Z.
- Text A: Herzhystasstörungen
- Text B: Glossar zu Text A (Herzrhythmusstörungen)
- Text C: Patientenbroschüre Defibrillator
- Text D: Informationen über die Medikamente Apin, Tenormin Amiodaron und Noctamid, (Gelbe Liste)
- Text E: Differentialdiagnose: Ausschluss organischer Erkrankungen
- Text F: Pharmakotherapie der Agoraphobie und der Panikstörung

Dem Psychologiestudenten/ der Psychologiesticudentin liegen folgende Materialien vor:
- Fallbeispiel Herr Z.
- Text G: Differentialdiagnose: Ausschluss anderer psychiatrischer Erkrankungen
- Text H: ICD-10 F4: Neurotische, Belastungs- und somatoforme Störungen
- Text I: Ätiologie und Störungsmodelle
- Text J: Psychotherapeutischen Behandlung von Panikattacken

Für diese Vorbereitung stehen Dir 15 Minuten zur Verfügung.

Also bis ________ Uhr
2 List Provided with Materials “Frau K.”

Bitte lese die Fallbeschreibung sorgfältig durch und unterstreiche wichtige Informationen. Weiterhin stehen Dir Lehrbuchtexte zur Verfügung. Verschaffe Dir bitte in der vorgegebenen Zeit einen groben Überblick, welche Texte Dir zur Verfügung stehen und welche Themen sie behandeln (wenn Du willst, kannst Du Dir Notizen machen oder etwas unterstreichen). Die Zeit reicht an dieser Stelle nicht, um die Texte ausführlich zu lesen! Dazu wirst du später noch Gelegenheit haben.

Dem Psychologiestudenten / der Psychologiestudentin liegen folgende Materialien vor:

- Fallbeispiel Frau K
- Text A: Differentialdiagnose: Ausschluss psychiatrischer Erkrankungen
- Text B: ICD-10 F3: affektive Störungen
- Text C: Ätiologie und Pathogenese depressiver Erkrankungen
- Text D: Akuttherapie affektiver Erkrankungen

Dem Medizinstudenten / der Medizinstudentin liegen folgende Materialien vor:

- Beispiel Frau K
- Text E: Multiple Sklerose
- Text F: Glossar zu Text E (Multiple Sklerose)
- Text G: Informationen über die Medikamente Natil, Imurek und Ubretid
- Text H: Differentialdiagnose: Ausschluss organischer Erkrankungen
- Text I: Organisch affektive Störung
- Text J: Antidepressiva
- Text K: Therapie depressiver Erkrankungen

Für diese Vorbereitung stehen Dir 15 Minuten zur Verfügung.

Also bis _______ Uhr
Appendix B: Cases

1 Case “Herr Z.”


In den zwischenzeitlich vergangenen eineinhalb Jahren ist Herr Z. zehn mal, meistens als Notfall und nachts, in Krankenhäuser gebracht oder vom Hausarzt behandelt worden. Ur-plötzlich und unerwartet in verschiedenen Situationen, teils auch ohne für den Patienten sichtlichen konkreten Anlass, beginne sein Herz zu

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1 The cases have been developed by Franz Caspar and Katrin Schornstein.
rasen, er sei schweißgebadet und seine Brust schmerze, er habe extreme Angst zu sterben. Seine Kehle fühle sich wie zugeschnürt an, es bereite ihm große Schwierigkeiten, selbst den Arzt zu verstündigen.

Daraufhin befragt, gibt Herr Z. an, wenn der Arzt einen Hausbesuch dann zugesichert habe oder er sich im Taxi auf dem Weg ins Krankenhaus befinde, fühle er oft bereits nach wenigen Minuten, dass sein Herzasen abnehme, sich seine Atmung normalisiere und die Brustschmerzen nachlassen würden.

Neben den geschilderten Herzbeschwerden fühle er sich – vor allem direkt nach den Herzanfällen – wie in Watte gepackt und als ob alles nicht mehr funktioniere, er fühle sich insgesamt einfach körperlich unwohl. Zudem klagt Herr Z. auch über massive Einschlafstörungen; obwohl er jeden Abend automatisch eine Tablette Noctamid®2 ca. eine halbe Stunde vor dem Zubettgehen einnehme, könne er oft nicht gut einschlafen. Oftmals nehme er zusätzlich eine weitere Tablette, bevor an Schlafen zu denken sei. Wenn er am nächsten Morgen aufwache, fühle er sich häufig noch länger ganz benebelt und sei sehr müde.


Er habe nur noch den Beruf als Immobilienmakler, indem er sich immer mehr überfordert fühle. Die Besichtigung abgelegener Häuser und das häufige Treppensteigen strengte ihn doch sehr an, lieber regle er Geschäfte telefonisch vom Büro aus. Selbst Geschäftsreisen, die er früher gerne unternommen habe, fürchte er nun. Ein Bekannter berichtet, dass er, bevor er losfahre, sich die Adressen von Kardiologen und Notfallkliniken am Reiseziel und manchmal auch auf dem Reiseweg notiere.


2 Case “Frau K.”


Frau K. kommt mit dem Anliegen, sich in sozialen Situationen besser durchsetzen zu können.

So werde sie zum Beispiel oftmals von einer früheren Klassenkameradin zu sich eingeladen. Bisher habe sie immer die Einladungen ausgeschlagen, da sie der Klassenkameradin ihre Versorgung nicht habe zumuten wollen. Vor dem letzten Klassentreffen habe sie sich nach langem Überlegen dazu durchgerungen, die Einladung doch anzunehmen, zumal die Klassenkameradin als Altenpflegerin arbeite und somit daran gewöhnt sei, anderen beim Toilettengang behilflich zu sein.


Nach dieser Kur habe sie vermehrt unter Niedergeschlagenheit, Lust- und Mutlosigkeit gelitten. Des weiteren hätten sich ihre Ängste verstärkt, z.B. nicht mehr


Im Gespräch ist zu bemerken, dass Frau K. oftmals den Faden verliert, es wird deutlich, dass starke Gedächtnis- und Konzentrationsstörungen vorliegen.
Appendix C: Experimental Setting

Room 1

Room 2

Control Room (Experimenter)
Appendix D: German Summary

Die vorliegende Dissertation entstand im Rahmen des DFG-Projektes "Netzbasiertes kooperatives Lernen mit ausgearbeiteten Kooperationsbeispielen und Kooperationsskripts bei komplementärer Expertise" von Prof. Dr. Hans Spada und Prof. Dr. Franz Caspar. Das Projekt ist Teil des DFG-Schwerpunktprogramms „Netzbasierte Wissenskommunikation in Gruppen“, das von Prof. Friedrich Hesse (Tübingen), Prof. Ulrich Hoppe (Duisburg) und Prof. Heinz Mandl (München) im Jahre 2000 initiiert wurde.


Zwei instruktionale Methoden zur Förderung der Kompetenz zu guter, zielführender Zusammenarbeit in einem solchen Szenario wurden entwickelt und empirisch untersucht (1) Modelllernen anhand eines ausgearbeiteten Kooperations-
(1) Die zentrale Frage der Modellbildung war, ob das Beobachten eines ausgearbeiteten Beispiels einer gut strukturierten Zusammenarbeit eine effektive Methode darstellt, um zu lernen, was relevante Aspekte guter Kooperation sind und um nachhaltig die eigenen Kooperationskompetenzen zu verbessern. In diesen Ansatz flossen Erkenntnisse aus drei Forschungsbereichen ein: (1) Lernen anhand von ausgearbeiteten Lösungsbeispielen (Renkl, 1997; Van Lehn, 1996), (2) Modelllernen anhand von aufgezeichneten Lehrdialogen (Stenning, McKendree, Lee, Cox, Dineen und Mayes, 1999), sowie (3) Ergebnisse zur „Behavior Modeling“-Technik (Goldstein & Sorcher, 1974; Decker, 1984).


Eine experimentelle Untersuchung zur Evaluation der Lernwirksamkeit der entwickelten instruktionalen Unterstützungsmaßnahmen wurde durchgeführt:


In der Untersuchung wurden die Modell- und die Skriptbedingung verglichen mit einer Bedingung in der sowohl während der Lernphase als auch während der Anwendungsphase kooperative Fallbearbeitung ohne weitere Unterstützung stattfand und einer Kontrollbedingung ohne Lernphase (siehe Tabelle 2). In jeder Bedingung wurden 9 Dyaden untersucht.

Tabelle 2: Der Versuchsplan im Überblick

<table>
<thead>
<tr>
<th>Modellbedingung</th>
<th>Skriptbedingung</th>
<th>Bedingung ohne Skript</th>
<th>Kontrollbedingung</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lernphase (Fall 1)</td>
<td>Modelllernen anhand eines ausgearbeiteten Beispiels netzbasierter kooperativer Fallbearbeitung</td>
<td>Lernen von einer netzbasierten kooperativen Fallbearbeitung mit Kooperationsskript</td>
<td>keine Lernphase</td>
</tr>
<tr>
<td>Anwendungsphase (Fall 2)</td>
<td>Netzbasierte kooperative Fallbearbeitung</td>
<td>Netzbasierte kooperative Fallbearbeitung</td>
<td></td>
</tr>
</tbody>
</table>


Literaturangaben


Appendix E: Further Publications

1 Journal Articles and Articles in Peer-Reviewed Proceedings


2 Conference Contributions


