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Learning to collaborate while being scripted or by observing a model

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Abstract In an earlier study, we had tested if observing a collaboration model, or alternatively, following a collaboration script could improve students' subsequent collaboration in a computer-mediated setting and promote their knowledge of good collaboration. Both model and script showed positive effects. The current study was designed to further probe the effects of model and script by comparing them to conditions in which the learning was supported by providing elaboration support (instructional prompts and a reflective self-explanation phase). In addition, we applied a newly developed, innovative rating scheme to analyze the collaborative process: The rating scheme combines qualitative evaluation with quantitative assessment. Forty dyads were tested, eight in each of the following conditions: model plus elaboration, model, script plus elaboration, script, and control. Observing a collaboration model with elaboration support yielded the best results over all other conditions on measures of the quality of collaborative process and on outcome variables. Model without elaboration was second best. The results for the script conditions were mixed; on some variables, even below those of the control condition. The results of the current study lead us to challenge the positive view on collaboration scripts prevalent in CSCL research. We propose adaptive scripting as a possible solution.

Keywords Computer-mediated collaboration · Collaboration script · Elaboration support · Observational learning · Worked-out collaboration example

Introduction

In the face of a growing specialization of domain knowledge, collaboration of specialists from different disciplines is required in many new learning and working contexts. Often these people will be spatially distributed, making it necessary for them to use modern

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communication technologies to collaborate at the distance. Take the following example: The collaboration of psychologists and physicians is increasingly regarded to be of importance for the well-being of patients. Some symptoms can indicate both a physical as well as a mental diagnosis, making it difficult for an individual psychologist or physician to devise the correct diagnosis and, in consequence, the appropriate treatment. Then, a relevant question is how to encourage and support collaboration among locally distributed medical and psychological practices. In this context, video conference systems have been advocated as a particularly advantageous solution (Köhler and Trimpop 2004). Video-mediated communication systems support complex synchronous interactions (Finn et al. 1997) as participants in different locations can communicate via audio–video connection. In addition, application sharing technologies enable collaborators to not only view, but also jointly edit text or visual material.

Research on collaboration has, however, made it clear that not all collaboration is effective, but that the fruitfulness of collaboration depends on characteristics of the interaction (Barron 2003; Dillenbourg et al. 1995). Effective collaboration must be learned and requires guidance, instruction, and training (Slavin 1992). This is even more so when the challenges of a computer-mediated and interdisciplinary interaction are added to those of collaboration as such. Over the past years, numerous research projects in CSCL and CSCW have investigated ways to provide support for computer-mediated collaboration. In this context, our research focus is on pedagogic support measures, that is, on measures that aim at instructing collaborators in ways that enable them to collaborate well and with success subsequently. In a first experimental study (Rummel and Spada 2005b) we tested providing a collaboration model or a collaboration script as instructional methods to promote graduate students' ability to collaborate well and with good results in a complex computer-mediated setting, and to promote their knowledge of what makes good collaboration. Compared to two control conditions (one with the possibility to learn from prior unsupported practice, and one without any prior learning experiences) both model and script showed positive effects in a subsequent, unsupported collaboration on three levels: (a) the collaborative process (i.e., the way dyads collaborated), (b) the outcomes they obtained jointly, and (c) their individual knowledge about characteristic features of a good collaboration assessed in a posttest. The current study was designed to probe the learning effect of model and script further by supporting the elaborative/metacognitive processing of the relevant, instructional elements.

What is good collaboration?

Before we turn to our pedagogical approaches for promoting good and successful collaboration, we must first set the stage and discuss what characterizes such. Unfortunately, a comprehensive theory of collaboration generally, and of computer-mediated collaboration more specifically, is missing. Therefore, we have integrated empirical findings from different strands of research in an attempt to define characteristics of a good collaboration in a computer-mediated collaboration setting like the one sketched at the beginning of this paper (for a more detailed description, see Meier et al. 2007). At a general level, good collaboration can be characterized alongside five dimensions: communication, information processing, coordination, interpersonal relationship, and motivation.

To start with, the success of any kind of collaborative activity depends on the communication between its participants. Speaker and listener must collaborate on "grounding" their conversation (Clark 1996), that is, on *sustaining mutual understanding*.

Establishing and sustaining a "common ground" is a constant challenge in communication, and particularly difficult when collaborating partners have different levels of proficiency or come from different disciplinary backgrounds (Jucks et al. 2003; Nickerson 1999) or communicate in a computer-based setting (Clark and Brennan 1991). Speakers must tailor their contributions to their partner's presumed knowledge level ("audience design"; Clark and Murphy 1982). Listeners, on the other hand, are responsible for giving positive evidence of their understanding or ask for clarifications (Clark and Brennan 1991). In face-to-face conversation, this is usually achieved via eye contact or short verbal and nonverbal acknowledgments. However, in computer-mediated communication, participants need to employ more explicit feedback strategies, like verbal acknowledgements or paraphrases (Clark 1996). Similarly, computer-mediated communication requires more explicit strategies for *dialogue management*. Usually turn-taking is governed by implicit rules (Sacks et al. 1974) that ensure relatively smooth transition in face-to-face communication. However, already small transmission delays in video-mediated communication can severely disrupt these implicit mechanisms (O'Conaill and Whittaker 1997). Thus, more explicit strategies have to be employed by participants in computer-mediated settings, like handing over turns explicitly by asking a question or naming the next speaker (O'Conaill and Whittaker 1997).

Collaborative problem solving requires participants to pool and process their complementary knowledge in a process of group-level information processing (Hinsz et al. 1997; Larson and Christensen 1993). Like face-to-face groups, partners in computer-supported collaboration must avoid a general tendency of discussing primarily such pieces of information that were known to all group members from the start (Stasser and Titus 1985). The failure of collaborating partners to pool their unshared knowledge resources is especially problematic in a situation where the group members mutually depend on each other's knowledge to successfully complete the collaborative task (Johnson and Johnson 1992). Such a situation is given in the present scenario through the distribution of complementary expertise in the dyad (Rummel and Spada 2005b). Meta-knowledge about each other's knowledge bases and domains of expertise, that is, a transactive memory system (Wegner 1987), will facilitate the pooling of information (Larson and Christensen 1993; Moreland and Myaskovsky 2000; Stasser et al. 1995). Eliciting information from one's partner (i.e., asking questions) and externalizing one's own knowledge (i.e., giving explanations; Fischer and Mandl 2003; Webb 1989) are mechanisms that support *information pooling*. On the basis of the pooled information, collaborators must then make decisions concerning their joint solution. These decisions should be preceded by a process of critically evaluating the given information, collecting arguments for and against the options at hand, and critically discussing different perspectives (Tindale et al. 2003) before *reaching consensus*.

Particularly in complex, non-routine tasks, coordination is a crucial factor for the success of collaboration (Malone and Crowston 1990, 1994; Wittenbaum et al. 1998). Coordination is necessary to handle interdependencies that arise when subtasks build upon each other, when time is limited, or when group members depend on the same resources (Malone and Crowston 1990, 1994). In planning their work, collaborators must take into account their individual resources and fields of expertise (Hermann et al. 2001). The *task* should be *divided* accordingly and individual work phases should be scheduled so that collaborators can bring their individual domain knowledge to bear. On the other hand, joint phases are necessary for working on more integrative aspects of the task and ensuring a coherent joint solution (Hermann et al. 2001). In order to *manage time constraints*, a time schedule should be set up (Malone and Crowston 1994). In computer-mediated collaboration, the aspect of *technical coordination* needs to be addressed in addition to task division and time management (Fischer and Mandl 2003). Shared applications, for example, constitute resource interdependencies that can be managed by setting up allocation rules (Malone and Crowston 1990).

Integrating complementary (domain) knowledge for the joint solution will best be achieved in an interpersonal relationship which is characterized by a respectful, collaboratively oriented social interaction and the partners' equality in contributing to problem solving and decision making (Dillenbourg 1999). We refer to this as a "*reciprocal interaction*".

Finally, successful collaboration depends on participants' *individual motivation* and their commitment to their collaborative task (shared task alignment, Barron 2000). Individual collaborators will employ volitional strategies to keep up a high level of expended effort in their contribution toward the joint task, including focusing their attention on solution-relevant information or nurturing positive expectations regarding the collaborative outcome (Heckhausen 1989). Possible motivation losses due to the group situation can be counteracted, for example, by strengthening individual accountability (Johnson and Johnson 2003).

In addition to the more general dimensions of good collaboration discussed above, *domain-specific aspects* can be identified. For instance, in solving psychiatric cases with combined psychological and physical pathology, specific successful "expert" procedures must be considered (Caspar 1997). In deriving a clinical diagnosis, it is important to ground one's assumptions from the case description by arguing precisely how the patient's symptoms relate to the diagnostic criteria. Here, it is 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, it is important to enable both partners to utilize their relevant disciplinary knowledge, while at the same time ensuring the consistency of the joint work product.

The dimensions of good collaboration introduced in this section were the basis for developing the instruction provided to participants by means of presenting them a model collaboration or guiding them through a scripted interaction. Further, the dimensions are mirrored in the analytic categories we applied in analyzing the collaborative process data (see also Meier et al. 2007).

Two pedagogic approaches to instructing collaboration: Model and script

One pedagogic approach to instructing people about how to best collaborate that we are interested in is providing them with a model of a successful computer-mediated collaboration. The idea behind this approach is that, as they observe the solution steps and the behavior of the model partners, future collaborators may learn what aspects to pay attention to during their own collaboration. Evidence from different strands of research supports this assumption. Ample research on observational learning has demonstrated the instructional power of observing model behavior in a great variety of learning contexts (e.g., Bandura 1986, 1977; Bauer 1999; Decker and Nathan 1985). Also, research on learning from worked-out examples (e.g., Reimann 1997; Renkl 1997; VanLehn 1996) has demonstrated that "model" examples can be a successful means to teach students cognitive skills in physics or mathematics. Of more particular relevance for the present research: Researchers from the Vicarious Learner project at the University of Edinburgh (Stenning et al. 1999; Cox et al. 1999) have yielded evidence that studying exemplary dialogs can support the acquisition of dialog competence. Against the background of this research, we have hypothesized—and, in fact, were able to establish evidence (see Rummel and Spada 2005b)—that observing the worked-out example of a well-structured computer-mediated collaboration constitutes a promising method to learn relevant aspects of a good collaboration. We refer to the model collaboration as “worked-out collaboration example”. This indicates that our model collaboration is specifically designed to exemplify aspects deemed constitutive of a good collaboration. Such aspects were identified by means of a review of research on collaborative problem solving and learning (Rummel and Spada 2005b). An “exemplary collaboration” was derived from the literature review and, consequently, a screenplay was written incorporating the relevant theoretical aspects. When writing the screenplay, we also made use of excerpts of collaboration recordings from our earlier study. The screenplay was then executed as a dialog by professional actors, and recorded. The recorded model dialog was integrated with text animations illustrating the development of the joint (model) solution. A multimedia presentation resulted, similar to a video, however, divided into a number of discrete scenes. The model presentation illustrated how the model collaborators went about coordinating their collaboration, how they managed their time, and how they made use of their complementary domain knowledge in the problem-solving process.

The second pedagogic approach we have taken relates to a well-researched method to support collaboration: scripts. The main idea of collaboration scripts is to promote a fruitfully structured interaction by giving precise instructions on how to interact, thus improving the joint problem solving and knowledge acquisition. By enforcing specific kinds of activities among the collaborators, scripts are expected to prompt cognitive and social processes by participants that might otherwise not occur. The effectiveness of scripts for supporting face-to-face collaboration (O’Donnell and Dansereau 1992; for an overview, see O’Donnell 1999), as well as collaboration in computer-mediated settings (Fischer et al. 2007) has been demonstrated broadly. However, collaboration scripts have also been criticized (Dillenbourg 2002) for dictating interaction in a coercive way, thereby preventing the independent, exploratory thinking required for generative learning or problem solving and decreasing student motivation. Negative effects can be expected in particular if collaboration is scripted over an extended period of time and over many collaborative sessions (Rummel and Spada 2007). Against this background, we have raised the question if the central elements of a collaboration script could be learned from a scripted session. Such learning effect would make it unnecessary to continue the scripting and risk motivational drawbacks, but collaborators could themselves maintain a fruitful collaboration following the internalized script rules. Evidence in support of our hypothesis can be found in the literature on the Problem-Based Learning approach in medicine (e.g., Barrows 1986; Cameron et al. 1999). The central goal of this approach is to script students to be involved in constructive knowledge-building activities while solving authentic problems. In addition to the acquisition of contextualized domain knowledge, learners are expected to develop procedural knowledge of the clinical reasoning process (Barrows 1986). It is this emphasis on the acquisition of procedural skills in addition to domain knowledge where the Problem-Based Learning approach shares ground with our hypothesis that scripted collaboration may promote collaborative process skills. Moreover, the situated learning approach (Greeno and MMAP 1998; Lave and Wenger 1991) provides support for our hypothesis from a different angle: It supports our notion that meaningful collaborative activities guided by a script should yield much better learning effects (including better transferability to new collaborations) than direct instructions of the relevant script contents could. The results of our first study (Rummel and Spada 2005b) supported the hypothesis that scripted interaction can trigger learning about collaboration and thus improve subsequent collaboration. Our script was designed to be structurally equivalent to the model collaboration, that is, it instructed participants to engage in those activities that were demonstrated by the model collaborators. For example, while participants observing the model collaboration would listen to the model collaborators clarifying questions about the patient case at the beginning of their collaboration, participants in the script condition were instructed to do this together with their partner. It could be argued, therefore, that the two pedagogic approaches are, in fact, different ways of administering a script. The model asks the learners to observe the script, while the second approach guides learners to experience the script directly by leading them through a scripted interaction. Against this background, our research goal would be to find out which *mode of script administration* works best for learners to internalize the relevant script elements.

Promoting elaboration during learning from model and script

While we had established that observing a collaboration model or alternatively following a collaboration script during an initial collaboration can be effective in improving a subsequent unsupported collaboration (Rummel and Spada 2005b), there was reason to believe that learning from both model and script could be further improved by providing elaboration support. Of major relevance for the study presented in this paper are two means of promoting elaboration and learning: instructional prompts, and reflective self-explanations.

As Bandura (1977) pointed out, *model learning* depends to a great extent on paying attention to the relevant model stimuli, cognitively organizing and rehearsing what has been observed. Also, in research on learning from worked-out examples, instructional prompts and self-explanations have been shown to improve the processing of the examples and, consequently, learning of the demonstrated problem-solving strategies (e.g., Renkl 2002): Instructional prompts are short, attention-guiding explanations provided immediately before or after content is presented. They can be either descriptive, that is, giving a short summary or paraphrase, or principle-based, that is, pointing to the core elements or principles underlying the learning contents. Decker (1980, 1984) has shown the effectiveness of instructional prompts—he calls them "learning points"—for learning complex social skills, such as conflict management skills, from observing model videos. Furthermore, he found that descriptive prompts best support accurate reproduction of the observed, whereas principle-based prompts show their beneficial effects particularly when it comes to transfer and application (Decker 1984). Renkl (2002) provided evidence for the relevance of instructional prompts in learning from worked-out examples. Secondly, a great number of studies have demonstrated the effectiveness of self-explanations in supporting learning from worked-out examples and text (e.g., Chi et al. 1989; Ferguson-Hessler and de Jong 1990; Renkl et al. 1998). However, it has also become clear that self-explaining activities do not occur naturally, but that they have to be prompted and guided (Chi et al. 1994; Renkl et al. 1998). Collaborative self-explanations have been shown to be a particularly powerful way of supporting learning (Bielaczyc et al. 1994; Chi and Roy 2006). In the study by Bielaczyc and colleagues, dyads who engaged in collaborative self-explaining showed better cognitive and metacognitive learning activities. In the study by Chi and Roy, students who collaboratively self-explained while observing recordings of a tutor–tutee interaction learned more than individuals. We propose the term *reflective self-explanations* for the type of self-explanation activities that we are prompting in our study: *reflective* in that they require revisiting the observed example after observing it as a whole, and *self-explanative* in that they call for active sense making, discovering of relations, drawing of inferences—in short, the types of knowledge-building activities associated with self-explanations (Chi 2000). Renkl and his research group (e.g., Hilbert et al. 2004) demonstrated that, for best learning results, a transition should be made from providing instructional prompts to prompting self-explanations.

The relevance of instructional prompts for *learning from scripted problem solving* is supported by cognitive science literature on cognitive skill acquisition (VanLehn 1989) and research on expertise development (Bransford et al. 2000). Providing information about the conditions of successful problem-solving steps yields stable and flexible procedures. Along the same lines, it is a well-established fact that the knowledge of experts is "conditionalized on a set of circumstances" (Bransford et al. 2000, p. 31). Finally, already classical theories of human memory give evidence that content is retained better when put into a meaningful context (Craik and Lockhart 1972).

Also, reflecting on their scripted interaction is known to be important for improving students' collaboration even when script support is no longer offered. A study by Kramarski (2004) showed that prompting students to reflect on their scripted problem-solving process and on reasons for difficulties enhanced their collaboration and their problem-solving outcome. Furthermore, a study by King (1991) demonstrated that prompting students to reflect on their collaborative problem-solving process by metacognitive questions had an impact on following, unguided collaborations. She found that the instructions continued to influence students' interaction and problem solving even when no longer present. We believe that the concept of reflective self-explanations can also be applied to reflecting on one's own scripted practice afterwards. In that case, the scripted collaboration is being revisited and self-explanation activities are directed toward understanding and explaining one's own collaboration as the example.

Following the above argumentation, we conducted an experimental study to investigate whether learning from model and script could be further enhanced by providing instructional prompts and by eliciting reflective self-explanations. This study is presented in the current paper.

Method

Collaborative scenario and computer-mediated setting

Dyads composed of one medical student and one psychology student each were asked to collaborate in a computer-mediated setting and to jointly develop a diagnosis for complicated psychiatric cases. Two patient cases were designed to require medical and psychological domain knowledge in order to arrive at the correct diagnosis (i.e., the complementary domain knowledge represented in each dyad). For example, in case 1, Mister Z., the patient suffered from cardiac dysrhythmia, but also showed symptoms of a panic disorder. In case 2, Mrs. K., the patient had Multiple Sclerosis, but additionally showed symptoms of a major depression. The contents of the two cases did not overlap so that no transfer of conceptual knowledge was possible from case 1 to case 2. However, the cases were structurally similar in the sense that the requirements concerning the interweaving of medical and psychological domain knowledge were the same. For example, in case 1, sweating and palpitations are known side effects of the medication that Mr. Z. receives, but these symptoms can also be caused by the panic disorder. Similarly, in case 2, Mrs. K. complains about insomnia, which could be caused by the medication that she takes to treat her Multiple Sclerosis, but also by a major depression. For both patient cases, participants then had to discuss the symptoms against their domain knowledge and weigh up the arguments in favor of either possibility. The same cases had already been used in our first experiment (Rummel and Spada 2005b) and had proven suitable to produce the distribution of expertise and accountability we had aimed at.

Dyads collaborated via a desktop-videoconferencing system (VCON, ViGO professional) including personal text editors (Microsoft Wordpad) and a shared text editor (Groove). Thus, they could hear and see each other, and work separately as well as jointly on the required diagnosis.

Participants

The sample consisted of 40 dyads in total, specifically 8 dyads in each condition. Each dyad was composed of one psychology student and one medical student. Students were recruited during lectures and seminars; they received a financial compensation for their voluntary participation. All students were at an advanced level of proficiency in their studies. The mean age of the sample was 25 years. Given the difficulty of recruiting enough participants to fulfill our criteria for participation, we were unable to systematically vary the composition of the dyads with regard to gender. Most dyads consisted of two female participants (n=27), a number of dyads were mixed-gender (n=11). The rarest case was one male dyad.

We assigned students to dyads and dyads to conditions following the same rationale we had already utilized in our first experiment (Rummel and Spada 2005b). Prior to the actual study, a questionnaire was sent to students who had indicated an interest in participating, asking for information about: domain knowledge, computer literacy, and experience in working collaboratively.

The level of the students' prior *domain knowledge* was assessed by asking which semester they were in, and which courses they had attended so far. As we had information on the contents of the courses, we were able to assess their level of relevant domain knowledge at least indirectly.

To estimate the participants' *computer literacy* relevant for working in the present computer-mediated setting, we asked them to answer a number of multiple-choice questions: We asked for the extent to which they used the Internet and communicated via e-mail, chat, or newsgroups. We also asked how much experience they had with software applications like MS Word, Excel, PowerPoint, and other programs. Finally, we asked participants to assess their abilities in type writing.

With regard to their prior *experience with collaboration*, participants were asked to rate themselves on a five-point scale ranging from "very much" to "hardly any". Next, they were required to specify their collaborative experiences by indicating the context in which they had collaborated (in school or university, at the workplace, in a sports 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 students who did not meet this requirement were excluded from participation. A further reason for exemption was the participation in the first study (Rummel and Spada 2005b). Students were grouped into three levels of proficiency. Dyads were formed comprising people from the same level. The dyads were then randomly assigned to the four conditions, ensuring, however, that each condition included an equal number of participants from each level.

Experimental design

The experiment was composed of two phases. In the learning phase, the experimental variation was implemented. Five conditions were realized (see Table 1)—model-plus, model, script-plus, script, and control—and dyads collaborated and received instruction according to their condition. In the second phase of the experiment, that is, the test phase, dyads in all conditions collaborated without further support. In this phase, effects of the learning phase were assessed on three levels: (a) the collaborative process, (b) the joint outcome of the collaboration, and (c) the individual knowledge of important aspects of a good collaboration.

Implementation of the conditions

As mentioned above, model and script were designed to be structurally equivalent meaning that the script phases corresponded to model scenes. In the following paragraphs, we describe the design of both support methods in terms of the framework for collaboration scripts introduced by Kobbe et al. (2006) in the first article on this *ijCSCL* flash theme.

The collaborative scenario that lies at the heart of our script and our model instruction can be characterized as a jigsaw schema because the collaboration is based upon complementary domain knowledge of the partners. Kobbe et al. differentiate between script components, that is, elements a given script is composed of (participants, roles, activities, resources, groups), and script mechanisms, that is, functions regulating the relationships between the components (task distribution, group formation, and sequencing). The participants of our script and in our collaboration model are two people: a psychology student and a medical student. Accordingly, their role during the collaboration is to act as representatives of their professions: when diagnosing the case, the psychology student focuses on the psychological aspects, whereas the medical student is responsible for the medical aspects. These roles then form the basis of the distribution of resources and the assignment of particular activities. Resources available for the collaborative task are the case descriptions (one copy for each participant), the individuals' domain knowledge and, in addition, background material distributed to further increase the complementarity of the collaborative situation at the outset. For example, the psychology student was given a relevant part of the ICD (International Classification of Diseases, Chapter V [F]: Mental and Behavioural Disorders; World Health Organisation 1993) while the medical student received a manual describing the potential side effects of relevant medication. Table 2 illustrates the distribution of resources for case 1 (Mister Z.) which students are confronted with during the learning phase.

Table 1 Experimental design of study 2

Conditions	Learning phase: experimental variation implemented	Test phase: assessment of learning effects on collaborative process, outcome, knowledge
Model-plus	Observing collaboration model with elaboration support	Collaborating without further support
Model	Observing collaboration model	
Script-plus	Collaborating with script with elaboration support	
Script	Collaborating with script	
Control	Collaborating without support	

Table 2 Distribution of resources in collaborative scenario (case 1: learning phase)

Student of psychology	Medical student
case description: Mr. Z.	case description: Mr. Z.
Text A: differential diagnoses: exclusion of other psychiatric disorders	Text C: cardiac dysrhythmia
Text B: ICD-10 F4: neurotic, stress-related and somatoform disorders	Text D: information on side effects of Apirin, Tenormin und Amiodaron
	Text E: brochure on heart defibrillators
	Text F: differential diagnoses: exclusion of organic disorders
domain knowledge psychology	domain knowledge medicine

Dyads were formed based on the group formation mechanism that each dyad must be composed of one psychology student and one medical student, with comparable knowledge level in their domains as well as concerning computer literacy and experience with collaboration.

As was already stated, the task distribution, like the distribution of resources, was dependent upon the participants' role. Table 3 gives an overview of the script phases (sequencing) and the *activities* assigned to participants within each phase. The division of the collaborative process in phases of individual and joint work, the content of the specific phases, and their sequencing were based on our review of research on collaboration summarized in the introduction. Its appropriateness to trigger successful collaboration was supported by the results of our first study (Rummel and Spada 2005b).

Following the terminology used by Dillenbourg and Hong (2008), our pedagogical model represents a macro script in that it defines a sequence of phases with associated

Table 3 Script/Model phases and task distribution

Phase	Medical student	Student of psychology
1. Clarification of questions	Ask one another comprehension questions on case and technical terms of others' domain	
2. First ideas on possible solutions, formulation of questions to the partner.	Prepare explanations for the physiological disease, side effects of medication, differential diagnoses, and technical terms; reflect on which symptoms can be explained somatically and which not	Reflect on possible diagnoses, ICD-10 classifications, necessary medical clarifications and technical terms
3. Information exchange	Exchange information and discuss hypotheses for diagnosis, each partner is particularly responsible for information from is domain (see above individual phase)	
4. Formulation of individual solution parts	Formulate diagnosis part on differential diagnoses, causes for symptoms, and further medical examinations,	Formulate diagnosis part on ICD-10-diagnosis and justify from patients' symptoms.
5. Integration and discussion of individual parts,	Integrate individual text parts, each partner is responsible for his/her domain and his/her part of the solution.	
6. Revision of joint solution	Each partner revises his/her part.	
7. Final check of joint solution, integrate	Integrate changes, each partner is responsible for his/her domain.	

activities, but does not prescribe the collaborators' actions down to the level of the dialogue (as a micro script would do).

In accordance with findings discussed above, we designed the elaboration support for learning from model or script in the following way. Each model scene or alternatively each script phase was preceded by an *instructional prompt* directing the learners' attention to the relevant underlying principles (principle-based prompt). More specifically, participants in the model conditions were advised what they were going to *observe next*, whereas participants in the script conditions were pointed to the relevance of what they were going to *do next*. For example, preceding the initial clarification phase (see Table 3), a prompt would instruct students that in order to benefit from the complementary nature of their domain knowledge, they should start their collaboration by clarifying questions they may have on the case with the partner from the other domain. In addition to the instructional prompts, following the model presentation or the scripted collaboration, a *reflective self-explanation phase* took place in which dyads were encouraged to recapitulate the observed model collaboration or alternatively their scripted collaboration and explain to themselves what aspects had been important for the collaboration to be successful.

Procedure

After an initial introduction, all participants received training with the computer-mediated setting. At the end of the training, the partners were asked to engage in a short collaborative exercise to ensure that all participants had mastered the functions of the system needed for the collaborative activity. Next, the learning phase was administered.

Participants in the model condition observed worked-out scenes of the collaboration between a psychology student and a medical student on diagnosing case 1. The model collaboration was delivered as a multimedia presentation on the computer screen, similar to a video. The dialog between a pair of model collaborators was presented via audio recordings. In addition, animated text clips allowed participants to observe the development of the joint solution. The presentation showed how the model collaborators went about coordinating their collaboration: how they divided labor, taking into account their complementary domain knowledge; how they alternated between individual thinking or note taking and joint work; how they used each other as a resource in the problem-solving process; and how they managed time. Furthermore, the model dialog illustrated important aspects of the communication, particularly how the partners dealt with the mutual expert-layperson communication situation (i.e., each was expert in his own, but novice in the partner's domain): how they tailored their explanations to the knowledge level of the partner, how feedback and further inquiries were used to monitor understanding—in sum, how they developed and maintained common ground. The screen on which the model was presented closely resembled the desktop-videoconference setting in which participants later collaborated: the text-editors were located on the left-hand side of the screen (see Fig. 1; the screenshot depicts the joint text editor with the joint model solution); 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 seated in separate rooms—the same rooms from which they later collaborated via the desktop videoconference.

Dyads in the script condition were guided through their collaboration on case 1 by a collaboration script giving them instructions for their interaction. For example, while participants in the model condition listened to the model collaborators clarifying questions

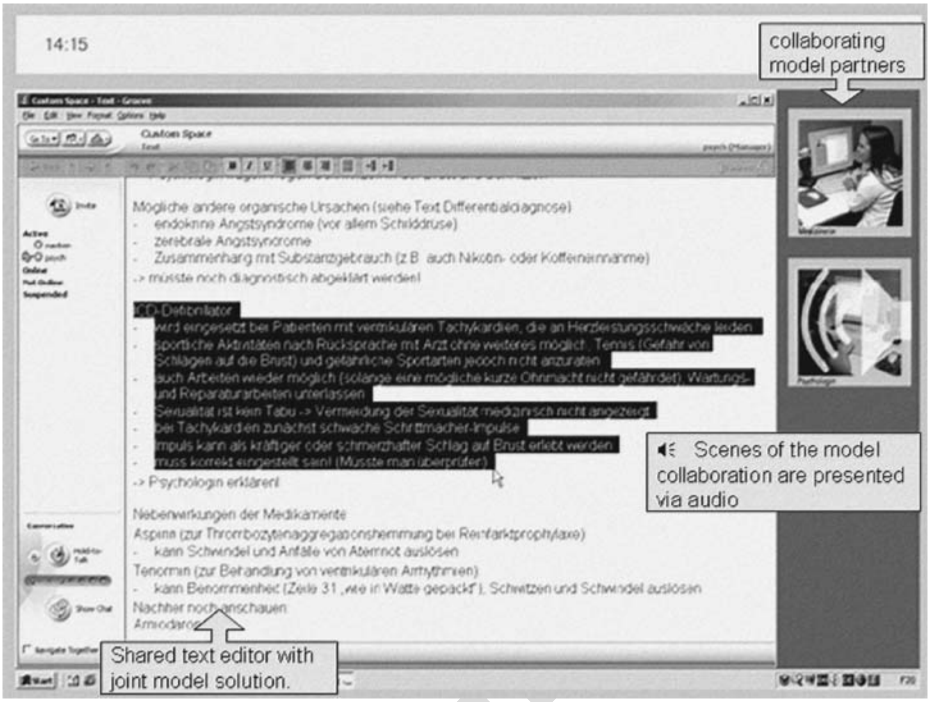

Fig. 1 Screenshot from the model collaboration

about the case at the outset of their collaboration, the participants in the script condition were instructed to do so with their partner. The script was provided on a second computer screen located next to the one participants used for their collaboration (i.e., for the desktop videoconference and the text editors). Each phase of the script was allotted a particular time frame. A small timer tool in the lower right corner monitored time; it gave students a 1-min warning and then another one when time was up. Figure 2 shows a screenshot from the collaboration script (script-plus condition).

The model-plus and the script-plus conditions were implemented correspondingly. As was described above, dyads in the model-plus and the script-plus condition received additional elaboration support: instructional prompts preceding each phase of model or script and a reflective self-explanation phase after the model observation or after the scripted collaboration, respectively.

Dyads in the control condition collaborated without further instructional support during both the learning and the test phase. By comparing an "unscripted condition"—equivalent to the current control condition—to an even more restricted control condition with no learning phase at all, it had been established in our first study (Rummel and Spada 2005b) that mere unguided collaborative problem solving on a task is as bad as having no opportunity for learning at all: The two conditions had not differed on any of the dependent variables. In this study, we decided to realize the "unscripted collaboration" condition as our control, because this condition maintains times in working with the partner and in using the experimental setting comparable to the other conditions. It is, therefore, a more rigorous control of learning effects potentially arising from our pedagogic measures.

The participants returned one day later for the test phase and the posttest. During the test phase, all dyads collaborated on case 2 without further instruction. Time on task was

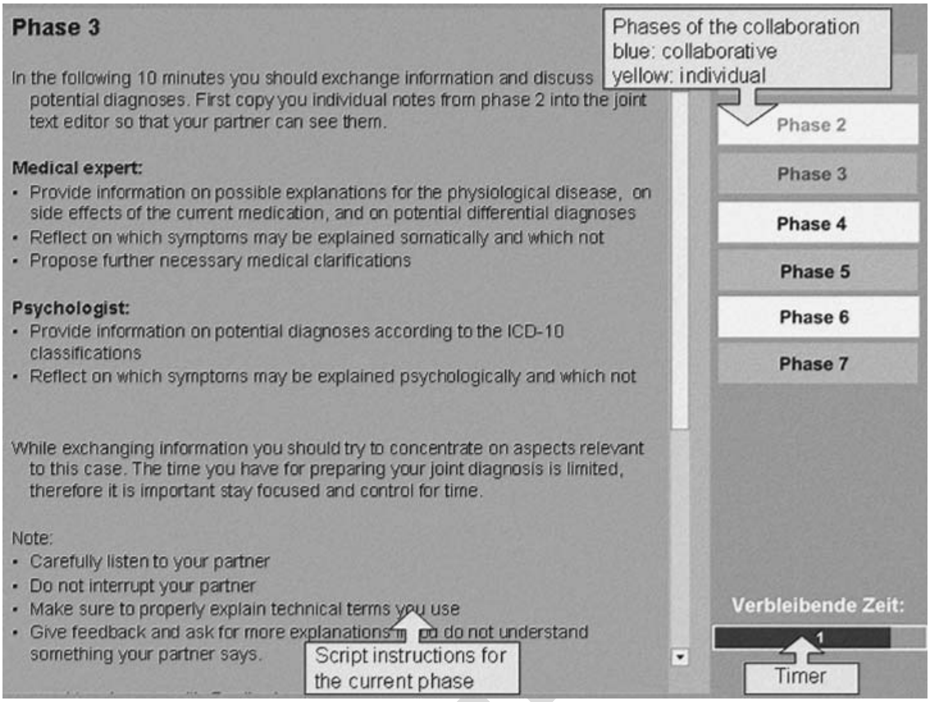

Fig. 2 Screenshot from the collaboration script (script-plus condition)

controlled: 55 min were allotted for the collaboration. Finally, each individual filled out the posttest and a questionnaire. During both learning and test phase, the two partners of each dyad were seated in different rooms and collaborated via the desktop videoconference.

Dependent variables

All dependent measures were assessed during the test phase (see Table 1), in which dyads in all conditions collaborated freely without further instructional support.

The collaborative process during the test phase was assessed employing a rating scheme that had been developed in the course of the process analysis for the first study (see Meier et al. 2007). This rating scheme allows the researcher to assess collaborative process in an economic fashion from video recordings and combines a qualitative with a quantitative approach, thereby avoiding some of the fallacies either one of them may have, when used solely to assess what is going on during collaboration (Rummel and Spada 2005a). It is qualitative in that the rater does not only determine the occurrence of utterances of a particular type as is done in many coding systems (cf. Strijbos et al. 2006). Rather the rater tries to understand and assess the interaction in its full complexity while watching the video recording, and then expresses his assessment on different dimensions in the form of ratings. This is the quantitative aspect of the system: taking the step from a qualitative impression to assigning a number.

The rating scheme comprises nine dimensions, which correspond to the characteristics of good collaboration outlined at the beginning of this paper: (1) *Sustaining mutual understanding* measures the extent to which participants express themselves intelligibly, for example, whether they explain technical terms when using them or whether they tailor their contributions to the knowledge of their partner. (2) *Dialogue management* assesses turn-taking and other aspects of communicative process coordination. (3) *Information Pooling* denotes the extent to which the partners take responsibility for their own domain, whether they see the partner as a resource to gather information from the other domain, and the extent to which information from both domains is referenced in the solution. (4) *Reaching consensus* evaluates the decision-making process, for instance, whether the partners critically discuss and mutually evaluate their arguments before coming to a decision. (5) *Task division* measures the extent to which the participants plan their solution process and divide the task in meaningful subtasks that are solved individually or in collaboration. (6) *Time management* assesses how participants deal with the time available for solving the task. (7) *Technical coordination* assesses whether technical resources such as the individual editors and the shared editor are used effectively and how participants deal with technical problems arising. (8) *Reciprocal interaction* examines whether the interaction is symmetrical, respectful, and whether both partners can contribute to their joint solution in equal shares. (9) *Individual task orientation* (psychology or medicine) is a dimension relating to motivational aspects in the behavior of the partners. Task orientation is the commitment of each partner to work towards solving the task, his or her willingness to put effort into the collaboration, and the extent to which volitional strategies are used. In contrast to all other dimensions, we assessed this dimension on the level of the individual rather than the dyad. Thus, effectively ten variables resulted from the process ratings.

Each dimension was rated on a five-point rating scale ranging from 0 (very bad) to 4 (very good). The rating handbook (for a translated version, see appendix in Meier et al. 2007) provided a detailed description for each dimension and gave a dialog example. The ratings were made as the rater watched the videotaped collaboration of a dyad. In order to reduce cognitive load on the raters and control for systematic biases in the observation, each dyad's videotape was segmented into thirds. The three parts were consecutively rated on the ten variables of the rating scheme. Cronbach's α across the three consecutive ratings was satisfactory (α>.61) for all dimensions. Finally, the three ratings for each variable were aggregated. These aggregated values are reported in the results section below. A second rater was asked to rate eight videos to safeguard the reliability of the rating system. As a measure of inter-rater reliability, the intra-class correlation (ICC, adjusted, single measure) was calculated. The ICC was found to exceed .80 for the three coordinative dimensions (task division, time management, and technical coordination) and to be close to .70 for sustaining mutual understanding and reaching consensus. The dimensions dialog management, information pooling, reciprocal interaction, and individual task orientation, reached ICC-values under .60. Thus, the results obtained with these five dimensions have to be interpreted with caution.

The *outcome* of the collaboration, that is, the joint diagnosis for case 2, was blind-rated by an expert who had no knowledge of the studies rationale and experimental design. The expert graded the diagnoses of all dyads on a scale from 5 (highest grade) to 1 (lowest grade) with intermediate steps at ×.3 and ×.7 (this partition is common in the German grading system). In addition to assessing the quality of the diagnosis concerning content, the clarity and logical configuration of the text were taken into account in the rating.

The *posttest* was filled out by each participant individually. It included an open-format question asking participants to describe to colleagues who were going to collaborate on a similar task how they should proceed in order to collaborate successfully. Participants' answers to this question were assessed by applying a checklist; a maximum of 16 points could be achieved. A second rater was asked to rate 20 (out of 80) posttests to safeguard the reliability of the assessment (ICC=.90). Posttest scores within each dyad cannot

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automatically be assumed to be independent. Therefore, we first calculated a Pearson's correlation between the partners. To calculate Pearson's correlation is recommended by Kenny and colleagues (Kenny et al. 2006, pp. 27) particularly if the collaborating partners belong to specified group that are not interchangeable. Because Pearson's correlation for this posttest was $r=0.37$ ($p=.02$), we cannot assume that the partners within dyads were sufficiently independent. Consequently, we calculated an average posttest score for each dyad and ran our analysis on these dyadic scores.

Finally, each student filled out a *questionnaire* including an adapted version of the Intrinsic Motivation Inventory (IMI; http://www.psych.rochester.edu/SDT/measures/intrins.html) based on the motivation theory by Deci and Ryan (1985), and a number of items to evaluate participants' experiences with the experimental setting. The IMI is composed of six subscales: interest/enjoyment, perceived competence, effort, value/usefulness, felt pressure and tension, and perceived choice. The validity of the IMI has been established by McAuley et al. (1989), and Tsigilis and Theodosiou (2003) reported on the reliability of Q1 a translated (Greek) version of the scale. We translated the postexperimental version of the IMI (http://www.psych.rochester.edu/SDT/measures/intrins_scl.html) into German and adapted it to our experimental setting. In our version, each subscale consisted of four items, which were rated by participants on a six-point rating scale (ranging from 1 = not at all true to 6 = very true). The reliability of all scales turned out to be satisfying (Cronbach's alpha between .75 and .90). Again, Pearson's correlations were calculated for the partners' scores to possibly justify including all individuals independently in the analysis. The correlations for all subscales of the IMI were between −.174 and .161, and none of them was significant. Therefore, it was justified to include the partners individually in our analyses.

Results

All tests were based on a Type I error probability of .05. Eta-square effect size estimates are provided in addition to the *p*-values. Based on our hypotheses, four a priori contrasts were computed comparing: (1) the script with the script-plus condition, (2) the model with the model-plus condition, (3) the model conditions with the script conditions, and (4) all four experimental conditions with the control condition.

A MANOVA was calculated over all ten dimensions of the rating scheme revealing a significant overall effect: $F\,(4, 35)=1.58$, $p=.031$, $\eta^2=.35$. Table 4 gives an overview of the results for each of the dimensions, and Table 5 provides the results for the four contrasts. On a number of variables, the model and script conditions showed positive effects on dyads' collaboration during the test phase compared to the control condition (contrast 4). Particularly clear effects were found on the process dimensions "task division" and "time management". For the process dimensions "dialog management", "information pooling", and "technical coordination", contrast 4 revealed the same result pattern. Here, the overall tests across conditions did, however, not reach statistical significance (see Table 4).

The results for contrast 3 shed further light on differences between the experimental conditions: on the dimensions "task division" and "time management", the script conditions performed lower than the model conditions (contrast 3; see Table 5). Moreover, the collaboration of the script dyads was rated lowest (even lower than in the control condition) on the process dimension "individual task orientation" for both the psychology student, P, and the medical student, M. The result for process dimension "individual task orientation" of the psychology student is shown in Fig. 3 to illustrate this result pattern. As was

Table 4 Collaborative process analysis (N=40): overall effects

	Model-plus M (SD)	Model M (SD)	Script-plus M (SD)	Script M (SD)	Control M (SD)	F (p)	η^2
Sustaining mutual understanding	2.29 (0.97)	2.13 (0.69)	1.67 (0.73)	1.79 (0.47)	1.79 (0.71)	1.03 (.40)	.11
Dialog management	2.04 (0.52)	2.33 (0.73)	1.87 (0.53)	2.25 (0.61)	1.60 (0.68)	1.80 (.15)	.17
Information pooling	2.75 (0.71)	2.69 (0.74)	2.25 (0.61)	2.52 (0.72)	1.88 (0.73)	2.09 (.10)	.19
Reaching consensus	1.64 (0.52)	2.31 (0.71)	1.67 (0.89)	1.88 (1.23)	1.44 (0.89)	1.14 (.36)	.12
Task division	3.13 (0.56)	2.58 (0.85)	2.13 (1.00)	2.08 (0.87)	1.29 (0.49)	6.04 (.00)	.41
Time management	3.04 (0.86)	2.25 (0.98)	2.00 (0.84)	1.71 (0.68)	0.83 (0.56)	8.10 (.00)	.48
Technical coordination	3.33 (0.31)	2.83 (0.69)	2.83 (0.67)	2.83 (0.59)	2.42 (0.58)	2.47 (.06)	.22
Reciprocal interaction	2.33 (0.80)	2.58 (0.50)	2.25 (1.07)	2.63 (0.70)	2.46 (0.53)	0.37 (.83)	.04
Individual task orientation (P)	3.08 (0.24)	2.92 (0.53)	2.38 (0.55)	2.38 (0.60)	2.50 (0.25)	4.08 (.01)	.32
Individual task orientation (M)	2.96 (0.45)	2.88 (0.59)	2.08 (0.79)	2.38 (0.68)	2.54 (0.50)	2.75 (.04)	.24

explained above, this process dimension aims at shedding light on a motivational aspect, the individual person's task alignment (Meier et al. 2007).

The result may, thus, indicate that dyads in the script conditions experienced motivational problems during their collaboration in the test phase. Interestingly, the self-report of motivation assessed by the IMI did not reveal such effects (see Table 8). We will come back to this result in the discussion section.

The script conditions also performed lower that the model conditions (in fact, again lowest) on the individual posttest on knowledge about collaboration (see overall effect in Table 8, and contrast 3 in Table 9), and with regard to the quality of their joint diagnosis evaluated by the expert rating (see Table 6). The overall effect for latter result did not reach statistical significance, but contrast 3 did (see Table 7).

Descriptively, the model-plus condition outperformed the model condition on most process variables (see Table 4). This result pattern is illustrated by the results of the task

Table 5 Collaborative process analysis (N=40): significant contrasts

	Contrast	T	p
Sustaining mutual understanding	–	–	–
Dialog management	4	2.12	.04
Information pooling	4	2.44	.02
Reaching consensus	–	–	–
Task division	3	2.72	.01
	4	3.85	.00
Time management	3	2.80	.01
	4	4.48	.00
Technical coordination	4	2.35	.03
Reciprocal interaction	–	–	–
Individual task orientation (P)	3	3.84	.00
Individual task orientation (M)	3	3.16	.00

Contrast 1: Script vs. Script-plus, Contrast 2: Model vs. Model-plus, Contrast 3: Model and Model-Plus vs. Script and Script Plus, Contrast 4: All Experimental vs. Control

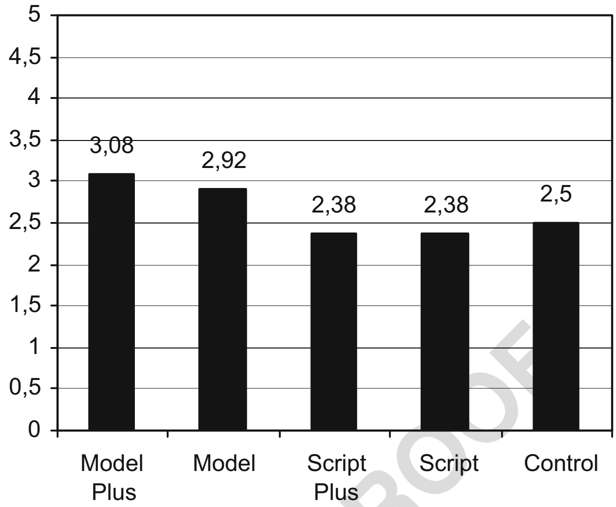

Fig. 3 Results for the process dimension: individual task orientation P (psychology student)

division (see Fig. 4). A similar descriptive pattern could not be shown for the script-plus versus the script condition. To the contrary, the script condition obtained better scores than the script-plus condition on most dimensions. However, neither contrast 2 (model vs. model-plus) nor contrast 1 (script vs. script-plus) yielded statistically significant results for the process dimensions. Only for the posttest did contrast 2 become significant (see Table 9)

Another interesting result pattern was found on the "pressure/tension" subscale of the IMI (see Table 8). Participants in the script conditions expressed they had felt less pressure/tension during their collaboration in the test phase, that is, their second—but first unscripted—collaboration (contrast 3; Table 9). Their ratings were even lower than those of students in the control condition. On the contrary, model condition participants expressed the highest amount of felt pressure/tension during their collaboration in the test phase, which, in fact, was their first collaboration. Overall, the ratings on this variable were relatively low (max possible was 6). We will discuss this result below. Descriptively, the results for the subscale "perceived choice" points in the same direction: Dyads in the model conditions rated their perceived amount of choice lowest of all conditions. This result did, however, not yield statistical significance. The MANOVA across all subscales of the IMI did reach significance: $F\,(4, 74)= 1.58$, $p=.034$, $\eta^2=.14$.

Discussion

In a first experimental study (Rummel and Spada 2005b), we had established evidence that observing a collaboration model, or alternatively, following a collaboration script, could improve students' subsequent, unsupported collaboration in a computer-mediated setting

Table 6 Quality of joint diagnosis (N=40): overall effect

	Model-plus M (SD)	Model M (SD)	Script-plus M (SD)	Script M (SD)	Control M (SD)	F (p)	η^2
Quality of joint diagnosis	3.40 (0.90)	3.96 (0.68)	3.09 (0.99)	2.76 (0.96)	3.26 (0.99)	1.89 (.13)	.18

Table 7 Quality of joint diagnosis (N=40): significant contrasts

	Contrast	T	p
Quality of joint diagnosis	3	2.35	.03

Contrast 1: Script vs. Script-plus, Contrast 2: Model vs. Model-plus, Contrast 3: Model and Model-Plus vs. Script and Script Plus, Contrast 4: All Experimental vs. Control

and promote their knowledge of good collaboration. The goal of the current study was to probe the learning effect of model and script further and compare them to conditions in which the learning was supported by providing collaborative elaboration support by means of instructional prompts and reflective self-explanation. We first discuss the results by pedagogical approach, before we turn to an overall discussion.

Learning from observing a model was again demonstrated to be a powerful pedagogic approach when trying to promote good collaboration in a computer-mediated setting. Dyads in the model conditions showed good collaborative behaviors and were able to put what they had learned about collaboration into words in the posttest. It is interesting to note that the two process dimensions where the model dyads profited most, concerned the planning and coordination of the collaboration in particular ("task division" and "time management"). They also yielded the best results with regard to the quality of the joint solution; however, this result did not become statistically significant. Yet another result revealed positive effects of the model conditions: We measured the perceived helpfulness of the learning phase in the questionnaire. Specifically, we asked participants about how useful they had found the learning phase (=phase 1) for their collaboration in the test phase (=phase 2) and whether they had tried to transfer experiences from the learning phase to the test phase. On both items, model participants gave higher ratings than script participants (see Tables 8 and 9 for the contrasts). It is noteworthy that the model conditions achieved their positive results against the background of a highly complex (computer-mediated and interdisciplinary) collaborative setting, and despite having observed only one single model collaboration. In fact, model participants experienced a relatively high amount of pressure

Fig. 4 Results for the process dimension: task division

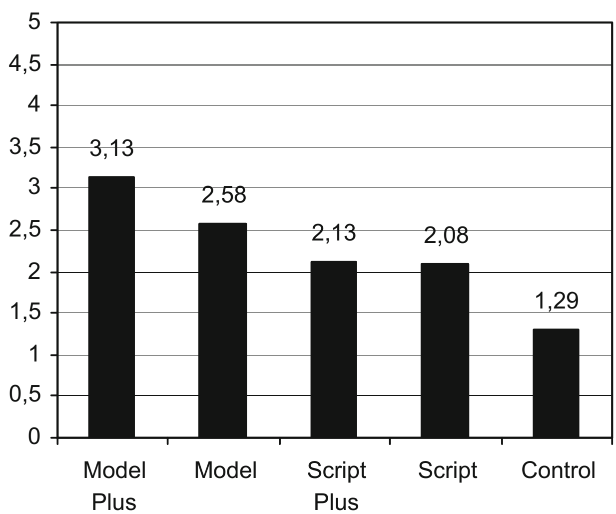

Table 8 Individual posttest and questionnaire: overall effects

	Model-plus M (SD)	Model M (SD)	Script-plus M (SD)	Script M (SD)	Control M (SD)	F (p)	η^2
Individual posttest (ANOVA) (average dyadic scores, *N*=40)							
Knowledge about good collaboration	8.63 (1.12)	6.75 (1.49)	6.09 (0.69)	6.09 (1.61)	6.47 (129)	5.66 (.00)	.39
Intrinsic motivation inventory (MANOVA) (*N*=80)							
Interest/enjoyment	5.14 (0.74)	4.97 (0.71)	5.44 (0.50)	5.30 (0.44)	5.14 (0.78)	1.20 (.32)	.06
Perceived competence	4.25 (1.03)	4.08 (0.90)	4.41 (0.89)	4.11 (0.69)	4.11 (0.74)	0.41 (.80)	.02
Effort/importance	5.15 (0.83)	5.15 (0.60)	4.77 (0.87)	4.66 (0.66)	4.94 (0.73)	1.40 (.24)	.07
Felt pressure/tension	3.38 (1.43)	3.15 (1.29)	2.21 (1.00)	1.88 (0.64)	2.44 (1.06)	5.13 (.00)	.22
Perceived choice	4.58 (0.81)	4.50 (0.79)	5.02 (0.64)	4.95 (0.64)	4.94 (0.79)	1.63 (.18)	.08
Value/usefulness	4.75 (0.86)	4.46 (1.11)	5.00 (0.74)	4.58 (0.76)	4.56 (0.96)	0.89 (.47)	.05
Items assessing experience with setting (MANOVA) (*N*=80)							
Found phase 1 useful for phase 2	5.38 (0.50)	4.69 (1.25)	4.60 (1.24)	4.00 (1.54)	4.73 (0.96)	2.62 (.04)	.13
Tried to transfer phase1 experience to phase 2	5.00 (0.63)	3.75 (1.24)	3.20 (1.08)	3.17 (1.27)	4.40 (1.30)	7.39 (.00)	.30

compared to the other conditions when trying to put into practice what they had learned during collaboration in the test phase as is illustrated by the significant effect found on the Intrinsic Motivation Inventory (IMI): the one for the pressure/tension subscale (see Table 8). The results of the current study also provided some evidence that elaboration support can further improve learning from a collaboration model. Descriptively, the model-plus condition outperformed the model condition on most process variables (see Table 4), however, the corresponding contrast 2 became significant only for the posttest (see Table 9).

On the other hand, the learning effects that had been demonstrated for the *script condition* in our first study (Rummel and Spada 2005b) could not be replicated to the same extent. While script condition dyads did show indications of having benefited from their first, scripted interaction in their collaborative behaviors during the test phase (see process

Table 9 Individual posttest and questionnaire: significant contrasts

	Contrast	T	p
Knowledge about good collaboration (average dyadic scores, *N*=40)	2	−2.99	.00
	3	3.60	.00
Interest/enjoyment (*N*=80)	3	−1.93	.06
Perceived compentence (*N*=80)	–	–	–
Effort/importance (*N*=80)	3	2,32	.02
Felt pressure/tension (*N*=80)	3	4.30	.00
Perceived choice (*N*=80)	3	−2.39	.02
Value/usefulness (*N*=80)	–	–	–
Found phase 1 useful for phase 2	2	−2.04	.06
Tried to transfer phase1 experience to phase 2	2	−3.60	.00
	3	−3.15	.00

Contrast 1: Script vs. Script-plus, Contrast 2: Model vs. Model-plus, Contrast 3: Model and Model-Plus vs. Script and Script Plus, Contrast 4: All Experimental vs. Control

dimensions), these effects were not reflected in the quality of their joint solution. Nor were participants able to make their tacit knowledge about good collaboration explicit very well in the posttest. Then, what have they learned during their scripted interaction on case 1? Possibly the concurrent demands of collaborating on the case, following the script instructions, and trying to reflect on the scripting on a meta-level in order to learn, were too high. Thus, the additional elaboration support in the script-plus condition obviously could not aid here as it added another layer to the already high demands. The result that students expressed having felt little pressure during their collaboration in the test phase, might be an indication of the relief they experienced when allowed to collaborate freely in the test phase. On the other hand, dyads' observable behavior during their collaboration in the test phase assessed by our process dimension "individual task orientation" indicated that they were less motivated than students in the other conditions. Why did such motivational problems not become apparent in the IMI?

In fact, the IMI scales did not reveal much at all. Students rated positive subscales high (e.g., interest/enjoyment subscale) and negative subscales low (e.g., pressure/tension) on average. Also, no other IMI subscale but "pressure/tension" revealed any differences across conditions. Self-report scales entail the danger that individuals attempt to present themselves in a certain way. The necessity to take into account psychological dynamics such as self-presentation or reactance is also mentioned explicitly by the authors of the IMI (see http://www.psych.rochester.edu/SDT/measures/intrins.html). It might well be that the external rating of a person's motivation as it can be inferred from utterances or actions in the context of a given situation is more objective than the person's self-report.

Although we acknowledge methodological limitations due to the relatively small number of dyads in each condition, the results of the current study are notable given the complexity of the setting. The promising main effect that could be established across our two studies is that collaboration can be improved through instruction. Whether the learning effects do sustain over time was not tested by our studies hitherto. We think this could be best investigated in a real-world collaboration setting. In conclusion, we would like to emphasize that observing a model appears to be a very powerful pedagogic strategy even when instructing complex social skills. This may point a promising direction for research on learning from worked examples. In a recent overview of worked-example research, Renkl (2005) argues along the same lines that it is time to take up the challenge of extending worked-example research to non-algorithmic domains. However, a caveat: The time expenditure for developing such models is very high. Secondly, we would like to plea for caution when advocating the beneficial effects of collaboration scripts. Collaboration scripts have recently become quite fashionable in CSCL research—and indeed: Scripted interactions often lead to better results than unscripted ones. However, so far not many researchers have been concerned with the question of how scripting affects learners' interactions after the termination of the scripting. The inconsistent results with regard to learning effects of collaboration scripts that we have found in our two studies clearly call for more research on this question. It appears that fading the script support over time (Wecker and Fischer 2007), or alternatively, providing script support in an adaptive fashion—only when needed—are the roads to proceed (Dillenbourg and Tchounikine 2007; Rummel and Weinberger 2008). With regard to the idea of providing adaptive script support, the question arises how this should be realized. Should collaborators be offered script support by request or should the scripting kick in when deficiencies in the collaboration are diagnosed? How can the need for support be diagnosed in real time? Such questions are in the center of interest in current research endeavors in CSCL (e.g., Gweon et al. 2006; Soller et al. 2005; Walker et al. 2008). However, while interest in adaptive support for collaborative learning is on the rise, little progress has yet been made on its implementation.

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