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Abstract

Collaborative learning in computer-supported learning environments typically means that learners work on tasks together, discussing their individual perspectives via text-based media or videoconferencing, and consequently acquire knowledge. Collaborative learning, however, is often sub-optimal with respect to how learners work on the concepts that are supposed to be learned and how learners interact with each other. One possibility to improve collaborative learning environments is to conceptualize epistemic scripts, which specify how learners work on a given task, and social scripts, which structure how learners interact with each other. In this contribution, two studies will be reported that investigated the effects of epistemic and social scripts in a text-based computer-supported learning environment and in a videoconferencing learning environment in order to foster the individual acquisition of knowledge. In each study the factors ‘epistemic script’ and ‘social script’ have been independently varied in a 2×2-factorial design. 182 university students of Educational Science participated in these two studies. Results of both studies show that social scripts can be substantially beneficial with respect to the individual acquisition of knowledge, whereas epistemic scripts apparently do not to lead to the expected effects.

Key words

Computer-supported collaborative learning, CSCL, cooperation scripts, computer-mediated communication, discussion boards, videoconferencing

Epistemic and social scripts in computer-supported collaborative learning

Collaborative learning builds on the idea that all learners of a group *elaborate* learning material together without direct or immediate intervention of the teacher (Cohen, 1994). For instance, learners may contribute and discuss divergent perspectives upon a theory that is supposed to be learned or discuss problem cases together. The collaborative learners may acquire knowledge as a consequence of being exposed to various perspectives and the need to refine or restructure their own point of view (Webb & Farivar, 1999). Individual group members contribute to joint task solutions, which in turn may change knowledge leading to modified contributions of individual learners. At least two dimensions of collaborative learning need to be analyzed: *epistemic activity* and *social mode of co-construction* (Fischer, 2001). Epistemic activities describe how learners deal with the learning task, e.g., how they categorize or define new concepts with the goal to (re-)construct knowledge (Fischer et al., 2002). Learners verbalizing their ideas on how to solve the task may re-structure their knowledge and refer to specific new concepts in order to produce more detailed solutions (Webb et al., 1995). The social modes indicate how learners interact with each other, e.g., how they relate their contributions to contributions of their learning partners in performing the epistemic activities. Learners may, for instance, ask each other questions or critically negotiate deviating perspectives and become aware of contradictions within their individual conceptual models. Learners may resolve contradictions which arise in discourse by constructing new knowledge (Piaget, 1932/1965; Nastasi & Clement, 1991). Studies to date point out that specific epistemic activities and social modes are predictive to outcomes of collaborative learning (Cohen, 1994; Fischer et al., 2002; Teasley, 1997).

There are indications, however, that learners do not spontaneously engage in productive epistemic activities and social modes and consequently, fail to achieve the desired learning outcome (e.g., Cohen, 1994; Mandl et al., 1996). With respect to epistemic activities, learners may, for instance, disregard important aspects of the learning material and try to make sense on grounds of their prior knowledge only, instead of applying new concepts to the problem at hand (Hogan et al., 2000; Salomon & Globerson, 1989). With respect to social modes, learners may try to quickly come to a consensus rather than critically refer to each others' contributions (Chinn & Brewer, 1993). In order for collaborative learning to be effective, learners may need to produce specific epistemic activities and social modes, such as defining and applying theoretical concepts or critically questioning each others' contributions (Fischer et al., 2002). Recent approaches have therefore aimed to facilitate these epistemic activities and social modes (Ertl, 2003; Weinberger, 2003).

Scripts for collaborative learning

Facilitating collaborative learning can be approached in numerous ways. Whereas some approaches, e.g., moderation of collaborative processes, may require complex skills and highly depend on the quality of the individual facilitator, *scripts* have been regarded as a qualitatively consistent possibility to facilitate collaborative learning activities (cf. O'Donnell, 1999). First, we will define scripts that aim to foster collaborative learning and introduce the prototypical MURDER-script as an example. Then we will outline scripts facilitating individual knowledge acquisition by specifically supporting epistemic activities and social modes of co-construction in collaborative learning.

Scripts are activity programs that aim to facilitate collaborative learning by specifying activities in collaborative settings, eventually sequencing these activities and assigning the activities to individual learners. Scripts *specify activities* in order to help learners identify and perform activities which are beneficial to collaborative learning and to avoid activities which may be detrimental. Typically, a teacher specifies discourse activities, which are believed to facilitate knowledge construction, prior to a collaborative learning phase. For instance, teachers first introduce students to the collaborative learning strategy of ‘question asking’. Subsequently, learners are expected to engage in the specified activities in the collaborative phase. Additionally, scripts can *sequence the specified activities*. This sequencing aims to assist learners to better interact with each other and apply superior strategies for working on the collaborative task. *Assigning activities* typically aims to warrant that the specified activities are carried out by all learners. This includes that learners are expected not only to engage in one specific activity, but also to take turns in assuming responsibility for various specified activities. For instance, one learner may be assigned the activity to ask questions regarding one specific problem and another learner may be expected to answer those questions. Then, these learners may switch their roles to work on a subsequent problem.

Scripts aim to facilitate the elaboration of collaborative learners by structuring their interaction. Scripts, however, can have counterproductive effects on elaboration if they “micromanage” what learners are to say and think (Cohen, 1994). Scripts that provide highly detailed guidelines may impede learners to think for themselves. This appears to apply in particular when learners are more experienced, i.e. when they hold internal scripts themselves (Kollar et al., 2003), and when the learning task is complex (Cohen, 1994). Therefore, we need to carefully investigate the conditions of productive scripts, such as learning task and detailedness of the script instructions.

The prototypical script, for example, aims to facilitate text comprehension by providing learning dyads with the MURDER-sequence (Dansereau et al., 1979; O’Donnell & Dansereau, 1992) First, the learners relax and concentrate on the task (*M*ood). Second, both learners read the first section of the text (*U*nderstand). Third, one learner reiterates the text section without looking at the text (*R*epeat). Fourth, the learning partner provides feedback (*D*etect). Fifth, both learners elaborate on the information (*E*laborate). Finally, both partners look through the learning material once again (*R*eview). This sequence prescribes affective, cognitive, and meta-cognitive activities to collaborative learners. Learners are expected to alternately engage in these activities for each text section and thereby more effectively constructing knowledge together. The prototypical script thus aims to facilitate various activity types at the same time, which is regarded as beneficial for learning. Larson et al. (1985), in contrast, compared the effects of scripts with *specific goal dimensions*, namely an elaborative and a meta-cognitive script. These scripts were modeled and instructed prior to a collaborative learning phase and emphasized elaborative activities of a “recaller”, such as personalizing information or using imagery to help remember the learning material, or metacognitive activities, such as error detection of a “listener”. The meta-cognitive script was detrimental for individual knowledge acquisition, whereas the elaborative script facilitated individual knowledge acquisition. Larson’s study thus indicates that differentiated effects of scripts with specific goal dimensions on collaborative learning can be expected.

Epistemic scripts

Epistemic scripts specify and eventually sequence knowledge construction activities. Epistemic scripts can guide the attention of learners towards specific aspects of the task and towards specific task-oriented activities while collaboratively discussing and constructing knowledge. Relevant concepts are made salient and may receive more elaboration by learners (Suthers, 2003). Epistemic scripts often provide some kind of visualization, such as a diagram or a table that contain central, yet abstract characteristics of the task discussed during learners’ collaboration. Epistemic scripts can assist the group in structuring the contents to be discussed and can provide ‘anchors’ for each learner to integrate new knowledge. Thus, epistemic scripts can be understood as task strategy, which can be more or less specific to the domain and the learning task. In contrast to social scripts, epistemic scripts may be applicable to individual learning scenarios too.

Brooks and Dansereau (1983), for instance, investigated a script that aimed at learning scientific theories and in-depth processing of the learning material. The script they called DICEOX, was represented as a table containing six columns for different aspects of the theory to be learned. In the first column *Description* learners had to describe the main theoretical concepts of the theory. In the second column *Inventor/History* learners had to take note of the historical beginning of the theory. In the next column *Consequences* learners took note of the implications, which could be made using the theory. The *Evidence* column was to be filled with empirical evidence for the theory and in the column *Other Theories* learners had to link the new learning material to their prior knowledge. The last column *Extra Information* was for additional information dealing with the context of the theory. Brooks and Dansereau (1983) were able to show positive effects of the script regarding prompted theory recall. However, this effect only showed up if an extensive training of the script took place in advance.

Dufresne et al. (1992), in contrast, provided questions for a problem-oriented learning task with the help of a computer-supported learning environment that learners were supposed to answer. The goal of this study was to help learners carry out hierarchically structured, expert-like problem analyses. Experts classify problems first and then apply a set of general procedures for solving problems (Chi et al., 1981). Thus, experts use a top-down approach, identifying the applicable theoretical concepts first and only then applying single concepts to specific problem case information. In order to support learners in applying (and acquiring) expert-like strategies, Dufresne and colleagues provided questions that were sequenced to be consistent with this top-down expert procedure. First of all, learners were asked to select and define a theoretical principle that could be applied to solve a learning task. Secondly, questions guided learners in applying theoretical principles to the problem. The results of their study show that collaborative learners can be successfully supported with this epistemic script. Dufresne and colleagues (1992) concluded from their findings that the script guided the attention of learners towards expert task strategies and supported learners in applying them. The effectiveness of epistemic scripts may need to be investigated further for learning with collaborative tasks. Herrenkohl and Guerra (1998) provided collaborative learners with task strategies including predicting and theorizing, summarizing results, and relating predictions and theories to results. These task strategies were introduced to each student as the framework for discussion prior to collaborative class activities. Only if these task strategies were additionally assigned to individual learners of one group did the collaborative learning processes and outcomes improve, which led Palincsar and Herrenkohl (1999) to argue

> [...] that providing a set of tools to guide students in constructing scientific explanations is not sufficient to ensure high levels of engagement and collaboration. To deeply engage students with the cognitive content and with other participants in the classroom, they need to be given roles with concomitant rights and responsibilities. (p. 169)

As epistemic scripts aim to guide the attention of the learners towards the task, learners may more frequently engage in specific task-oriented activities, which in turn has been reported to foster knowledge acquisition (Cohen, 1994). Thus, epistemic scripts may assist learners in working more productively on learning tasks. As the results of the studies indicate, however, epistemic scripts may need to be carefully designed. Providing learners with an epistemic script may not always result in individual knowledge acquisition. Furthermore, epistemic scripts may need to be endorsed by social scripts, e.g., which assign tasks to the different individual learners of one group.

Social scripts

Social scripts specify and sequence interaction of learners, such as eliciting information from each other by asking critical questions. These specific social interaction patterns are believed to motivate elaboration activities, which in turn foster learning. This does not mean, however, that any kind of social interaction may support learning. King (1999, p. 88) argues that "different types of interaction facilitate different kinds of learning". She suggests that "higher levels of learning" also require "higher levels of interaction" between learners. Social scripts, therefore, aim to help learners structure discourse according to successful interaction patterns of knowledge construction. Successful interaction patterns usually involve equal and alternating participation during discourse that is characterized by asking and answering questions, and critical negotiation (Chan, 2001; Doise, 1990; King, 1994; Teasley, 1997). When learners interact as suggested by the script, they should acquire more knowledge from collaborative learning tasks than 'unscripted' learners.

An important approach that applies social script components is, for example, *reciprocal teaching* (Brown & Palincsar, 1989). In reciprocal teaching, learners are provided with a structure of interaction for comprehending text material in small groups. The learners take different roles of 'teacher' and 'learner' during different tasks. The 'teacher's' task is to ask questions about the text that should be answered by the 'learner'. Then, the 'teacher' tries to summarize the main ideas of the text. If necessary, the 'learner' completes missing aspects. Thereafter the 'teacher' identifies difficult passages of the text and tries to clear them up in collaboration with the 'learner'. Reciprocal teaching, therefore, does not only suggest specific collaborative activities, such as questioning and supporting each other, but also provides a meaningful sequence of these activities in a social context. This structure of interaction, suggested by the social script of reciprocal teaching, tends to enhance collaborative learning. Learners may interact in a more conflict-oriented manner, aiming to clear up their own perspectives and integrating the perspectives of their learning partners. Social scripts may motivate collaborative learners to continuously refine their conceptual models, because they can guide learners' attention towards the fact that their contributions are being reviewed by their peer learners.

Summing up, scripts constitute instructional approaches that aim at facilitating collaborative learning. Despite the common goal, these structural aids can be designed in very different ways. *Epistemic scripts*, on one hand, aim to affect collaborative learning by prestructuring the learning task in order to facilitate knowledge construction activities. *Social scripts*, on the other hand, try to facilitate collaborative learning by structuring the interaction of learners. Scripts may aim to support collaborative learning activities that have proven to be positively related to learning outcome in the respective collaborative tasks, depending on prior knowledge of the learners, the learning task and the detailedness of the script prescriptions. It is unclear, however, what the different contributions of epistemic and social components of scripts to facilitating collaborative learning really are, because thus far epistemic and social script components have not been systematically compared.

Scripts in computer-supported learning environments

Scripts for collaborative learning have been studied extensively in face-to-face contexts. Yet recently, scripts have become increasingly important for *computer-supported collaborative learning (CSCL)*. In the context of CSCL, scripts can have different characteristics altogether depending on the type of computer application, which mediates the communication of learners (e.g., e-mail, chat, videoconferencing). This variety of applications complicates theoretical foundation, systematic research, and design of educational support in the context of CSCL. We, therefore, first provide a brief survey about applications for computer-mediated communication. Second, we illustrate how scripts may be implemented into various CSCL environments.

In CSCL environments communication of learners is typically mediated via the computer by a range of possible applications. Different computer applications typically imply different, namely *synchronous* and *asynchronous* forms of communication (see Weinberger & Mandl, 2003). In synchronous communication (e.g., based on chat or videoconferencing) the participants are expected to partake in discourse at the same time. The discussants expect, for instance, to receive responses from their discussion partners quickly. In asynchronous forms of communication, in contrast (e.g., based on e-mail or discussion boards), non-technical delays between individual discourse activities may take place. This means that participants can record the message and respond to it at a later, convenient time.

The various CSCL environments may require specific instructional approaches. Most script approaches are based on instructors that introduce and typically monitor how the script suggestions are meant to be applied. Apart from the fact that the introduction of scripts may take more time than the actual collaboration (see Hytecker et al., 1988), teachers introducing and monitoring scripts may compromise the idea of self-guided, collaborative, distant learning and require face-to-face encounters. Typically, remote learners may not be able to participate in prior face-to-face training programs. Therefore, scripts for CSCL have been induced via *design of the communication interface* (Baker & Lund, 1997; Hesse et al., 1997; Scardamalia & Bereiter, 1996). Hesse and colleagues (1997) argue that no medium was genuinely designed for collaborative learning and thus, the design of the medium interface could be modified and improved for specific collaborative learning scenarios. As an alternative to training students to follow a specific sequence of activities, scripts can be implemented in the interface of a CSCL environment. Scripts become part of the computer interface and may guide learners to engage in the specified activities of collaborative learning (see Dillenbourg, 2002). Scripted interfaces may, for instance, restrain access to the interface so that learners may take turns and contribute at specified times. Scripted interfaces may also prompt specific activities, e.g., asking a discussant to contribute a question. More specific questions need to be raised when considering scripts based on design of the communication interface: How are the instructions of the script presented and to what degree are the learners free (or coerced) to follow a structure given by the script?

Scripts can be realized with different *degrees of freedom* within CSCL environments. CSCL interfaces with few degrees of freedom may be designed for specific learning tasks and only allow task-oriented activities. Hron and colleagues (1997), for example, sequenced the interaction of learners in CSCL environments by alternately prompting two learners to propose modifications to solutions of learning tasks, explain the modification, and obtain agreement from the learning partner. Only when both partners reached agreement could they successfully access the interface and actually modify the task solution.

Interfaces with more degrees of freedom can guide collaborative learning by providing a selection of prompts (Scardamalia & Bereiter, 1996). Prompts are, for instance, sentence openers or question stems. The learners are expected to use prompts in the intended way, e.g., by completing a question stem. Scardamalia and Bereiter (1996), for instance, implemented prompts for their Computer-Supported Intentional Learning Environment (CSILE, now Knowledge Forum). In this environment, learners were expected to assign different given categories, such as 'problem', 'what I already know', 'new learning', and 'my theory' to their individual messages. These prompts aimed to foster specific collaborative task strategies. In this way, instructional support was implemented into the CSCL environment and learners were encouraged to engage in specific discourse activities while they collaboratively constructed knowledge online. Several researchers continued to build on this idea to apply scripts in CSCL environments with the help of prompts, even though it has been found, that learners rather ignore script suggestions in CSCL environments (Veerman & Treasure-Jones, 1999).

Nussbaum and colleagues (2002), for instance, provided learners with a number of prompts called *note starters*, e.g., 'My theory is ....' or 'I need to understand,' which students could choose when starting to write a message in text-based CSCL environments. These note starters were implemented into the text window, which discussants used to formulate messages in online debate. The findings of this study showed that prompts could encourage students to explore and discuss alternative viewpoints in comparison to unscripted computer-mediated discussions. Thus, it can be said, that prompts can have a positive effect on collaborative learning in text-based computer-mediated communication.

In videoconferencing, scripts may be implemented in a shared collaboration space, e.g., as a representation shared by the learners. Using application sharing, which can be regarded as a genuine feature of videoconferencing, the contents of this shared representation can be created and modified by learners. According to Zhang and Norman (1994), the representation of a task can suggest to learners how to solve a task in a specified way (*representational effect*). According to Suthers and Hundhausen (2001), this representational effect can be used to intentionally modify learners' (collaborative) activitites (*representational guidance*). The shared representation can visualize concepts and can make them salient. Concepts can also be made salient within the discourse of learners without explicit reference to the concepts if the representation is constructed in a particular way, e.g., a table (cf. Brooks & Dansereau, 1983) or prompts which have to be responded to (e.g., King, 1999).

To summarize, scripts implemented into the interface of a CSCL environment may suggest specific activities. Prompts can provide instructions, making explicit the expectations of the instructional designer and changing interaction when learners decide to use the prompts in the expected way. In the following sections we will present two empirical studies on scripts implemented by prompts into CSCL environments. We analyze the effects of epistemic and social scripts in CSCL environments that are based on two different media types (web-based discussion boards and videoconferencing technologies).

Two empirical studies on social and epistemic scripts in CSCL environments

Based on the outlined framework, we arranged and investigated two different CSCL environments with epistemic and social scripts: (1) a text-based problem-oriented peer discussion environment and (2) a videoconferencing-based peer-tutoring environment. In both of these studies we focused on the question, to what extent epistemic and social scripts affect the individual knowledge acquisition outcome of collaborative learning.

Study 1: Scripts in text-based problem-oriented peer discussion environments

Text-based computer-mediated communication enables new, asynchronous collaborative learning scenarios, in which learners are supposed to engage in more active, reflective, and socially supported knowledge construction (Clark et al., 2003; Scardamalia & Bereiter, 1996). Therefore, text-based computer-mediated communication can be seen as a suitable technology for learners to jointly explore complex problems by contributing their individual perspectives in order to acquire knowledge. Study 1 focused on analyzing and facilitating problem-oriented collaborative learning among peers to improve individual knowledge acquisition as the learning outcome. Therefore, an epistemic and a social script were designed in a text-based peer discussion environment with the help of prompts that prestructured the discourse of collaborative small groups (Scardamalia & Bereiter, 1996; Weinberger et al., 2002; 2003).

The *research question* of study 1 was: What are the effects of an epistemic script and a social script and their combination on the individual acquisition of knowledge as the outcome of collaborative learning in a text-based computer-supported peer discussion environment? On the grounds of the theoretical framework on collaborative learning outlined above, we expected that both scripts would enhance individual knowledge acquisition in comparison with an unscripted CSCL environment. However, the use of both epistemic and social scripts would additively combine the effects of both components and, therefore, lead to the best learning outcomes.

Sample and design of study 1

Ninety-six students with the average age 23 (*SD* = 4) in their first semester of Educational Science at the University of Munich participated in this study. The students participated in groups of three in an online learning session about attribution theory (Weiner, 1985), a standard part of the curriculum. Participation was required for receiving course credit at the end of the semester. Students were invited individually – each student to one of three different laboratory rooms. Each group of three was randomly assigned to one of the four experimental conditions in a 2×2-factorial design. Learning partners did not know each other before the experimental session. We varied the factors 'epistemic script' (with vs. without) and 'social script' (with vs. without). The experimental groups did not differ with respect to age, first language or prior knowledge. The university students, however, disposed of very little prior knowledge in general. Therefore, prior knowledge differences could not be reliably measured due to a floor effect. Furthermore, randomization of the four experimental groups was effective with respect to important prerequisites of CSCL like learning strategies, social anxiety, uncertainty orientation, computer-specific attitudes, and interest towards the learning environment.

Learning environment of study 1

Students in all conditions had to work together in applying theoretical concepts to three case problems that were presented online as a text, and jointly prepare an analysis for each case by communicating via web-based discussion boards (figure 1). They were asked to discuss the three cases using the attribution theory and to jointly compose at least one final analysis for each case, i.e., they typically drafted initial analyses, discussed them, and wrote a final analysis. The cases portrayed typical attribution problems of university students, e.g., a student interpreting his failure in an important test:

> "I have never liked text analysis – not even at school! And now? Because of this stupid course I failed a test for the first time ever! My girlfriend simply told me, 'Never mind, after all 50 percent of the students didn't pass.' But I just don't like text analysis. I am simply not talented at it at all. Well, I don't need to become a translator of literature. Interpreter or teacher of Spanish wouldn't be bad either, now would it? I really enjoy oral practice in contrast to text analysis, you know? I am really gifted at speaking Spanish – it was a piece of cake to learn that language."

All groups collaborated in three web-based discussion boards – one for each case. The web-based discussion boards provided a main page with an overview of all message headers. In this overview, answers to original messages appeared in outline form. The learners could read the full text of all messages, reply to the messages, or compose and post new messages. In the replies, the original messages were quoted out with '>' as in standard newsreaders and e-mail programs.

The experimental conditions in study 1

Control group. The participants of the control group were allowed to access the three distinct web-based discussion boards of the CSCL environment. Within these discussion boards, new contributions could be posted that started a discussion thread or existing messages could be answered in order to continue a thread. The participants were introduced to the various technical functions of the discussion boards. The collaborative phase ended automatically after 80 minutes.

Epistemic script. The CSCL environment in the condition 'epistemic script' was the same as in the control group except for the epistemic script. The epistemic script aimed at facilitating how the learners worked through the learning task. With the help of prompts, learners were suggested to apply theoretical concepts to the problem cases. When composing a new message that represented the initial contribution to a discussion thread, epistemic prompts prestructured the input window (see table 1), i.e., the learner's message already contained prompts. These prompts were questions about the case and aimed at supporting the learners in identifying relevant case information, in applying concepts of Weiner's (1985) attribution theory to case information, and in predicting and proposing pedagogical interventions regarding the case.

Social script. The participants in the experimental condition 'social script' had exactly the same techniques at their disposal as in the control group, but were further provided with the social script. The social script aimed to foster critical negotiation in order to avoid quick and false consensus and foster elaboration. For this reason, each student in the social script condition was assigned two roles: (a) analyst for one of the cases and (b) constructive critic for the other two cases. Role (a) included taking over the responsibility for the preliminary and concluding analysis of one case and responding to criticism by the learning partners. In their role (b) as a constructive critic, the learners had to criticize the analyses of the two other cases presented by the learning partners. These activities were supported by the prompts of the social script (see table 2), which were automatically inserted into the critics' messages and into the analyst's replies in order to help learners successfully master their roles. Students were given a time limit for each of the required activities. The students were guided through all three cases and were asked to alternately play the role of the analyst and of the critic.

The combination of epistemic and social script. In the combination condition 'epistemic + social script', participants were provided with the same CSCL environment as in the control group, except for the epistemic and the social scripts. All initiating messages were prestructured with the epistemic script. The distribution of the roles, including the social prompts as well as the timer-controlled guidance through the three discussion boards with the single problem cases, was identical to the 'social script' condition. In other words, the first and the concluding messages of the analyst were prestructured with the epistemic prompts and the responses were prestructured by the social prompts. As in any of the experimental conditions, the collaborative phase lasted 80 minutes.

Procedure of study 1

After a test of prior knowledge based on a problem case, the students were asked to individually study a three page description of the attribution theory. Then, the learners were briefly introduced to the respective prompts and/or the handling of the learning environment. After this individual phase, the learners worked together on three cases. The collaboration was followed by an individual post-test based on yet another problem case which paralleled the individual pre-test. Time-on-task was three hours in all four conditions.

Data sources, dependent variables, and instruments of study 1

The learners' individual analyses of the post-test case were taken as data sources to determine *individual knowledge acquisition*. Two raters segmented the learners' case analyses (87% interrater-agreement) and classified the segments with respect to individual knowledge acquisition. On the grounds of an expert solution, correct and relevant relations between theoretical concepts and case information were identified within the individual analyses. For instance in the above case example, the case information of a student who failed a test and said, 'I am simply not talented at it at all', would be appropriately related by the participants to the theoretical concepts of a stable and internal attribution according to Weiner's (1985) attribution theory. Learners who related the case information 'no talent' to a stable, internal attribution, applied theoretical concepts to the problem case. The frequency of these explicit relations in the participants' post-test case analyses were counted as indicating individual knowledge acquisition. The indicator of individual knowledge acquisition was thus the sum of all relevant and correct relations between theoretical concepts and case information, which could be identified in the individual case analyses after the collaborative learning phase. The classification of the segments corresponded sufficiently between the two raters ($\kappa = .90$).

All measures are reported with z-scores calculated over the entire sample for better comparability. An ANOVA was performed to determine main and interaction effects of the two scripts. An α-level of .05 was used for the statistical tests of significance.

Treatment check

It has been checked if the treatments were realized by the participants in the intended way. Prompts of both scripts should have been answered according to the intention of the individual prompt. For instance, the prompt of the social script “WE HAVE NOT REACHED CONSENSUS CONCERNING THESE ASPECTS:” should have been followed by an actual difference of opinions between the learning partners. In any other case, the prompt has been coded as ‘not answered in the intended way’. Therefore, the treatment check consisted of the assessment of responses to the prompt that diverged from the intention of the prompt. Additionally to unintended responses, missing responses to prompts were counted and entered the treatment check. The results of the treatment checks are calculated in relation to the number of prompts of the individual conditions. Additionally, the social script guided learners through the individual discussion boards of the problem cases and pre-structured the number of the messages that the participants should contribute. This number of messages was the same for all participants (eight messages in total). Therefore, the number of messages will be analyzed as additional treatment check of the social script.

Results of study 1

Treatment check. On average, about 60 % of the prompts were responded to in the intended sense. No substantial differences with respect to the usage of the prompts could be found between the three experimental groups that were facilitated by prompts ($\chi^2_{(2)} = 2.48$, *n. s.*). This analysis is based on a comparison of the groups of three with any form of cooperation script ($n = 24$). With respect to the number of messages, the main effect of the social script can be considered to be substantial ($F_{(1,28)} = 16.05$; $p < .05$). Furthermore, no effect of the epistemic script ($F_{(1,28)} = 2.89$; *n. s.*) and no interaction effect ($F_{(1,28)} = 2.99$; *n. s.*) can be found. The participants provided with the social script authored less messages than participants without social script in the control group ($M = 49.13$; $SD = 18.72$) and the group with epistemic script only ($M = 35.00$; $SD = 13.58$). Learners with social script wrote about eight messages each (equals 24 messages within a learning group of three), with ($M = 25.50$; $SD = 1.93$) or without ($M = 25.63$; $SD = 2.07$), additional epistemic script, which was intended. The smaller deviations from the suggested 24 messages in the social script conditions can be explained by handling mistakes or messages that were written in addition to script suggestions.

Individual knowledge acquisition. The post-test analysis shows two main effects of both types of scripts on individual acquisition of knowledge (see figure 2). First of all, ANOVA revealed a large negative effect of the epistemic script ($F_{(1,28)} = 6.89$; $p < .05$; $\eta^2 = .20$). The means of both of the epistemic-script conditions are remarkably lower than the mean of the control condition. Second, there was a medium-sized positive effect of the social script ($F_{(1,28)} = 3.56$; $p < .05$; $\eta^2 = .11$). As figure 2 shows, the learners in the combined scripts condition learned even less than the learners in the control condition. An interaction effect, however, could not be found ($F_{(1,28)} = 1.32$; *n.s.*). These results indicate that the individual acquisition of knowledge could be facilitated with the social script, whereas the epistemic script impeded the learning outcome. Although the ‘epistemic script’ participants acquired knowledge in comparison to the pre-test, they did not do as well as they could have without the epistemic script. Both script components, in fact, proved to be additive in their effects, however, this was only partially coherent with our assumption due to the negative contribution of the epistemic script.

Discussion of study 1

The results show that *individual acquisition of knowledge* as learning outcome of collaborative learning can be influenced both positively and negatively by scripts implemented into computer-supported text-based peer discussion environments.

The *social script* proved to support the individual acquisition of knowledge. The facilitation of specific interaction patterns in collaborative learning appears to be particularly relevant with respect to the facilitation of individual acquisition of knowledge. Social scripts may, therefore, reinforce collaborative learning mechanisms. Collaborative learners are exposed to diverging perspectives about a subject matter and need to elaborate and refine their conceptual models in order to evaluate and eventually integrate the various perspectives.

The *epistemic script* was detrimental to the individual acquisition of knowledge. The epistemic script might not have fostered the *internalization* of concepts. The epistemic script may have limited processes of reflective thinking about the cases in functioning like a checklist. The epistemic script may have facilitated the application of theoretical concepts as long as the script was available to the learners, but did not support the participants in developing their own conceptual understanding as internalized knowledge structures. Furthermore, the specific mechanisms of collaborative learning may have been impeded in the sense that learners did not need to integrate diverging perspectives, but were given a task strategy, which was acknowledged as being correct and which enabled them to solve the task on their own.

Study 2: Scripts in a videoconferencing environment

In the second study, we investigated effects of scripts in a *videoconferencing-based peer teaching environment*. Videoconferencing enables synchronous forms of collaborative distance learning, which are required when learners need to interact at high frequency. Despite these conveniences, videoconferencing does not yet play a prominent role for the design of CSCL environments. One reason, of course, are the technical demands users have to face, particularly the availability of audiovisual equipment and reliable bandwidth. Results from earlier studies (Geyken et al., 1998; Guzley et al., 2001) indicate that videoconferencing is particularly suited for peer-tutoring respectively peer-teaching settings. These settings are characterized by situations in which a peer-tutor directly interacts with the tutee or student when the latter faces a learning problem and therefore needs assistance. The tutor's tasks are to give explanations or feedback when needed, but also to ask questions in order to help the partner finish the learning task. Peer-teaching through videoconferencing may be a particularly effective method of collaborative learning when more experienced tutors guide tutees through multiple aspects of the learning material. Student tutors often lack the skills to elaborate on the learning material together with the tutee, however, and concentrate on only conveying theoretical concepts.

With these considerations in mind, in study 2 we investigated a peer-teaching setting in which the learning partners collaborated via a videoconferencing system supported by an epistemic and a social script.

The *research question* of study 2 was: How do an epistemic script and a social script and their combination influence *individual knowledge acquisition* as outcome of collaborative learning in a videoconferencing-based peer-teaching setting? We expected that the epistemic script as well as the social script would foster the individual acquisition of knowledge. For the combination of the script components, we expected an additive effect, i.e., learners who are supported with respect to their epistemic activities and with regard to their social modes of co-construction should learn more than learners in the conditions with only one of the scripts.

Sample and design of study 2

Eighty-six students in their first semester of Educational Sciences at the Ludwig-Maximilians-University of Munich took part in this experiment. The students with an average age of 23 (*SD*=4) participated in groups of two in an online learning session about the theory of genotype environment effects (Scarr & McCartney, 1983), a standard part of the curriculum of Pedagogy in Munich. Participation was required for receiving course credit at the end of the semester. Dyads were set up and randomly assigned to one of four conditions in a 2×2-factorial design. Learning partners did not know each other before the experimental session. The partners were seated in two different rooms where they stayed during the experiment (see figure 3). We varied the factors ‘epistemic script’ (with vs. without) and ‘social script’ (with vs. without). Experimental groups of the four conditions did not differ with respect to age, first language or prior knowledge. However, as students were in their first semester, their prior knowledge was quite low. Furthermore, randomization of the experimental groups was effective concerning important prerequisites to CSCL like learning strategies, social anxiety, uncertainty orientation, computer-specific attitudes and interest towards the learning environment.

Learning environment of study 2

A desktop videoconferencing system including audio and video connections and a shared text editor to support the dyads’ knowledge construction allowed participants to verbally communicate and jointly create text material at the same time. The shared application was accomplished with Microsoft Netmeeting 3.01. As text editor we applied MS-Word 2000, an application that we expected to be well known among our participants and therefore easy to handle. This setting enabled the learners to alternately type or edit notes in the text-editor.

The experimental conditions in study 2

Control group. Dyads in the unscripted groups received no instructions regarding their interaction. According to the given time in the scripted groups, time-on-task was the same in all four experimental groups. The task for the tutor was to explain the theory of genotype environment effects, the task of the learner was to acquire knowledge on the theory of genotype environment effects. Furthermore, both learners had to elaborate on the learning material. Learners had a shared word document for typing notes and creating a shared external representation. However, in contrast to the scripted conditions, this shared document was without any prior structure.

Epistemic script. In the condition with epistemic script, the shared text document was structured by a table that included several content-related prompts, which were supposed to direct the dyads' discussion throughout this phase towards the learning task (see table 3). The structure of the script was adopted from Brooks and Dansereau (1983) and adapted in accordance with the purposes of our study. The epistemic script was divided into four sections consisting of two prompts each. The different sections stressed important aspects including concepts and main ideas of the theory, empirical findings, theory consequences, and individual judgments regarding the theory. Participants were asked to generate answers to all questions and write them down in the text document. Neither of the theoretical texts provided any information concerning the questions regarding the consequences and the individual judgment. By responding to these prompts, the participants were expected to draw conclusions that went beyond the scope of the texts.

Social script. In the social script condition, the text document included instructions about the roles of the tutor and the tutee in order to effectively direct the learners' interaction. This text document included a short description of the roles of tutor and tutee and directed the learners' interaction during the collaborative learning phase by defining four steps of interaction (see table 4): (1) explaining the text material (tutor) and asking comprehension questions (tutee), (2) typing the information received (tutee) and assisting the learner (tutor), (3) generating ideas concerning the theory (tutor and tutee individually), and (4) discussing (tutor and tutee) and writing down the results of the discussion (tutee only). *The combination of epistemic and social scripts*. Dyads in the condition with both treatments worked with a text document that included the epistemic prompts, as well as the instructions of the social script. Both were represented on the shared text editor. However, this shared text document could only be edited in phases two and four of the social script. In phases one and three, only the instructions and the prompts of the epistemic script were shown.

Procedure of study 2

The experiment was conducted in one session that consisted of two main phases. During an individual text acquisition phase, one learner of each dyad read a text, which contained a description of the theory of genotype environment effects (Scarr & McCartney, 1983). In the following cooperative learning phase, this learner took the role of a tutor. Correspondingly the other learner took the role of a tutee during collaboration.

Data sources, dependent variables, and instruments of study 2

We measured the *individual acquisition of knowledge* as outcome of collaborative learning on the basis of a cued recall test, which covered the main contents of the read theoretical text on genotype environment effects (Scarr & McCartney, 1983). The test contained open-ended questions in short answer style such as, *'Twin studies are evidence for …'*, as well as closedended questions in multiple choice format such as, *'Which factor according to Scarr's theory directly influences the child's IQ? a) Genotype of the parents b) Phenotype of the child c) Child's environment or d) Child's genotype'*. The score consisted of 50% multiple choice and 50% short answer items. The internal consistency of the test was measured with Cronbach's α and reliable with α = .70.

Treatment check

It has been checked if the participants have used the treatment in the intended way. This meant that learners needed to respond to the prompts of the epistemic script in the shared text editor by elaborations on theory and empirical evidence as well as personal elaborations concerning the prompts "educational consequences" and "individual judgment". Learners following the social script were expected to invest increased efforts in theory and personal elaborations. Time entered the treatment check analysis as covariate in order to assure comparability with study 1.

Results of study 2

Treatment check. Regarding work on theory, there was an effect of the social script ($F_{(1,38)}$ = 4.36; $p < .05$) indicating that learners with social script elaborated theory significantly more than learners without, while learners with epistemic script spent less effort on theory elaboration than learners without epistemic script ($F_{(1,38)}$ = 8.89; $p < .01$). There was a marginal effect that learners with epistemic script elaborated more on empirical evidence than learners without epistemic script ($F_{(1,38)}$ = 3.11; $p < .1$). Regarding personal elaboration, there was a significant effect of the epistemic script ($F_{(1,38)}$ = 59.98; $p < .01$), showing that learners with epistemic script produced much more personal elaborations than learner without epistemic script. Learners with social script also generated more than the double amount of personal elaborations than learners in the control group, but this effect was not significant.

Individual knowledge acquisition. Figure 4 shows the results concerning *individual knowledge acquisition* in study 2. The social script produced a positive effect on the 10% α-level ($F_{(1,39)} = 3.54$; $p < .10$; $\eta^2 = .08$), but no effect of the epistemic script could be found ($F_{(1,39)} < 1$; *n. s.*). The two factors did not interact ($F_{(1,39)} < 1$; *n. s.*). The effect of the social script was rather small, and contrary to our assumptions, the epistemic script had no facilitating effect on individual knowledge acquisition.

Discussion of study 2

Learners within the socially scripted conditions, on average, acquired more knowledge individually. These findings indicate that the *social script* can foster collaborative learning in a peer-teaching videoconferencing environment. The learners may have been enabled to more effectively take over their part as peer-teacher or tutee. In contrast, no outcome effect of the *epistemic script* could be identified. Possibly, learners already possessed successful strategies for concept-oriented, collaborative tasks, while the epistemic script suggestions were to some extent redundant.

General discussion

The two studies reported in this article conceived and investigated epistemic and social scripts to facilitate collaborative learning in a computer-supported learning environment. Rather than arranging the basic conditions (e.g., the group size), these scripts aimed to support specific epistemic activities and social interaction of collaborative learners (cf. Dillenbourg, 2002; O’Donnell & Dansereau, 1992). Several questions have been examined concerning how scripts may facilitate collaborative learning within computer-supported learning environments: Which process dimensions of collaborative learning should be fostered by scripts? How may scripts apply to CSCL environments based on different learning tasks and communication media? What effects on the individual acquisition of knowledge do computer-supported scripts have?

The two studies investigated the effects of different scripts in CSCL environments. The researched learning environments differed not only within the communication media (discussion boards vs. videoconference), but also in reference to the collaborative learning task (problem-oriented peer discussion vs. concept-oriented peer-tutoring), as well as the size of the group (two respectively three). Despite these differences, the two studies had in common that they investigated similar instructional interventions, which were adapted to the characteristics of the respective collaborative learning task: (1) epistemic scripts that structured *what* learners discussed to handle the group task and (2) social scripts that aimed to facilitate *how* learners interacted with each other. As the treatment checks show, computer-supported cooperation scripts are used flexibly by the students, but can still be a powerful tool to change interaction of learners. Despite the aforementioned differences of the two studies, epistemic and social scripts also had similar effects on individual knowledge acquisition. The social scripts of both studies fostered individual knowledge acquisition, even though in study 2, the social script only produced a marginal effect. The epistemic script of study 1 substantially impeded individual knowledge acquisition. The epistemic script of study 2 did not produce a significant effect on individual knowledge acquisition, even though learners with the epistemic script acquired knowledge below average. Thus, we need to put the results into perspective and differentiate further, what and how epistemic activities and social interaction were influenced by the different scripts in each study. Based on these and prior findings, we can extend our understanding of how epistemic and social scripts need to be re-designed to foster individual knowledge acquisition.

The results of the two studies indicate that scripts may facilitate the individual acquisition of knowledge. In particular, it was found that in both CSCL environments the *social scripts* were able to enhance the individual acquisition of knowledge, as was hypothesized. Social scripts may support interaction of learners, which in turn appears to facilitate individual knowledge acquisition. Thus, social scripts may enable learners to actually exploit the aforementioned advantages of collaborative learning and support the elaboration and refinement of individual knowledge in social situations (Cohen, 1994; Herrenkohl & Palincsar, 1999). The differences between the social scripts applied in the two studies may be explained by the different roles the scripts support. Social scripts may be particularly effective, when they support roles which learners typically would not engage in. Collaborative learners without support from a social script with the roles of a constructive critic often build a minimal consensus in order to hastily complete collaborative tasks. Social scripts, however, may change interaction patterns and motivate learners to inquire about the contributions of the learning partners more critically and thereby acquire more knowledge individually than learners without additional support.

In contrast, the *epistemic scripts* of both studies did not show the expected outcomes. In study 1 the epistemic script actually hampered the individual acquisition of knowledge in comparison to the other experimental groups. There are indications that epistemic scripts can facilitate collaborative learning by guiding the activities of learners towards solving the task in a very specific way (e.g., Dufresne et al., 1992). Epistemic scripts might also, however, hinder the individual acquisition of knowledge if the script does not sufficiently motivate joint elaboration of the learning material. Whereas learners of study 2 where guided to *elaborate* on four specific categories (theory, empirical findings, consequences, and personal judgments) of the learning material, learners of study 1 only needed to *decide*, for instance, whether an attribution was internal or external. Thus, the diverging results regarding epistemic scripts could be explained due to the fact that the epistemic scripts of the two studies facilitated different degrees of elaboration of the learning material. Too much structuring may further impede interaction of learners; particularly when the script divides labor into tasks that can be worked on by each learner individually (Cohen, 1994).

As a consequence, not any kind of epistemic script may be generally recommendable for any collaborative learner and task. Epistemic scripts can make specific aspects of the learning task salient and suggest specific knowledge-building activities. Therefore, it is of utter importance, to take note of the aspects of collaborative tasks at which epistemic scripts aim, which epistemic activities are suggested by the scripts and the extent to which learners are supported by the scripts to elaborate the learning material. Negative effects of epistemic scripts may be ascribed to specific conditions of the script. Instead of simplifying the collaborative learning task by functioning like a checklist, scripts may need to facilitate elaboration beyond what could be observed in an unsupported discourse of learners. Instead of being provided with an approved, correct task strategy, learners could be prompted to construct a conceptual model themselves. In this line of thought, scripts sometimes may need to make tasks more difficult for learners and assign specific social modes to individual learners of one group, which they typically would not show on their own (Palincsar & Herrenkohl, 1999; Reiser, 2002). In order to improve epistemic scripts, we may need to investigate what specific epistemic activities should be fostered that are related to elaboration of learning material and with what kind of script design this may be achieved.

CSCL environments offer a suitable context for scripting interaction of learners. Clearly, there is further need to examine beneficial applications of scripts for CSCL. If scripts are to be applied in virtual seminars, for example, we need to understand more clearly how scripts can be applied over longer periods of time and how they interact with learners' internal scripts (Kollar et al., 2003). Therefore, an important question for future research of CSCL environments is how scripts can be designed to motivate the collaborative activities related to elaboration and knowledge acquisition. Motivating specific collaborative learning activities may, however, not only be a question of what specific activities that learners typically do not engage in on their own a script supports, but also a question of how many and what degrees of freedom for elaboration a script allows.

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Figure 1: The experimental setup with a learning group of three participants in separate rooms (upper section of the figure) and the CSCL environment with a web-based discussion board (lower section of the figure).

Figure 2: The individual acquisition of knowledge in z-scores in study 1 (standard deviations in brackets).

Figure 3: The experimental setup of the videoconferencing setting with a learning group of two participants in separate rooms.

Figure 4: The individual acquisition of knowledge in z-scores in study 2 (standard deviations in brackets).

Table 1: Epistemic script prompts of study 1.

Case information, which can be explained with the attribution theory:
Relevant terms of the attribution theory for this case:
Does a success or a failure precede this attribution?
Is the attribution located internally or externally?
Is the cause for the attribution stable or variable?
Does the concerned person attribute himself/herself, or does another person attribute?
Prognosis and consequences from the perspective of the attribution theory:
Case information which cannot be explained with the attribution theory:

Table 2: Social script prompts of study 1.

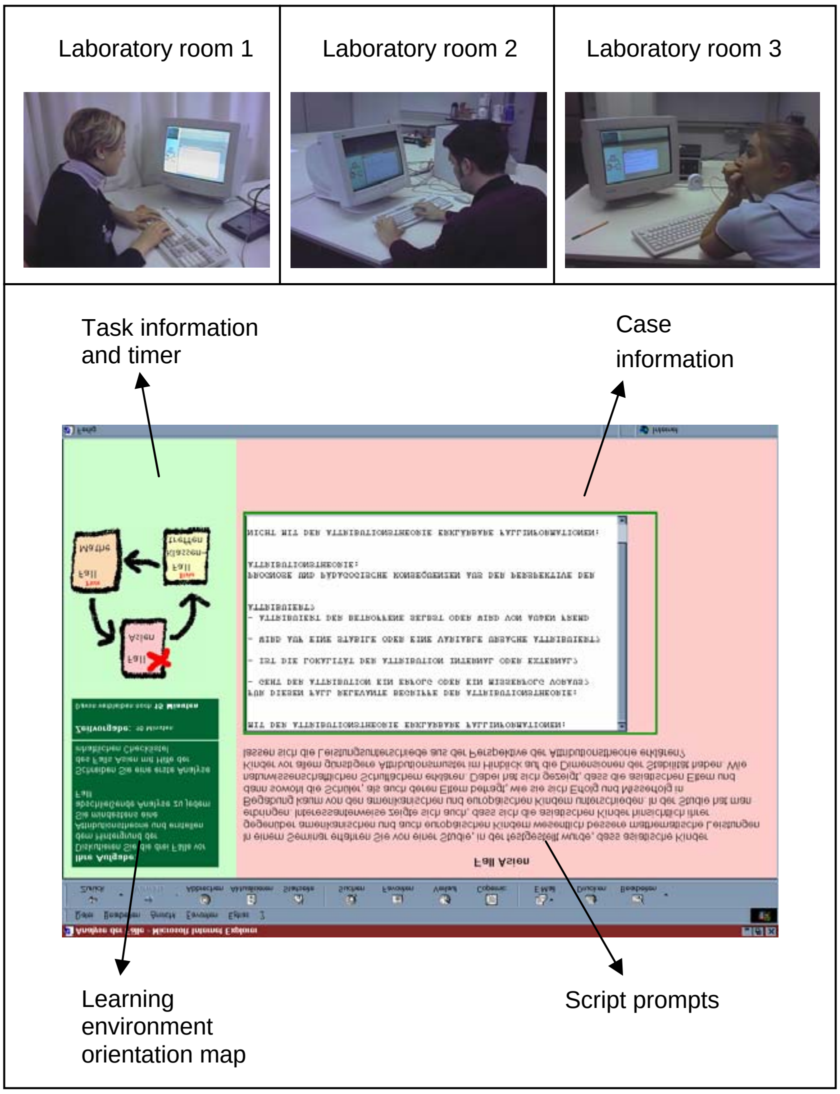
Prompts for the constructive critic
These aspects are not yet clear to me:
We have not reached consensus concerning these aspects:
My proposal for an adjustment of the analysis is:
Prompts for the case analyst
Regarding the desire for clarity:
Regarding our difference of opinions:
Regarding the modification proposals:

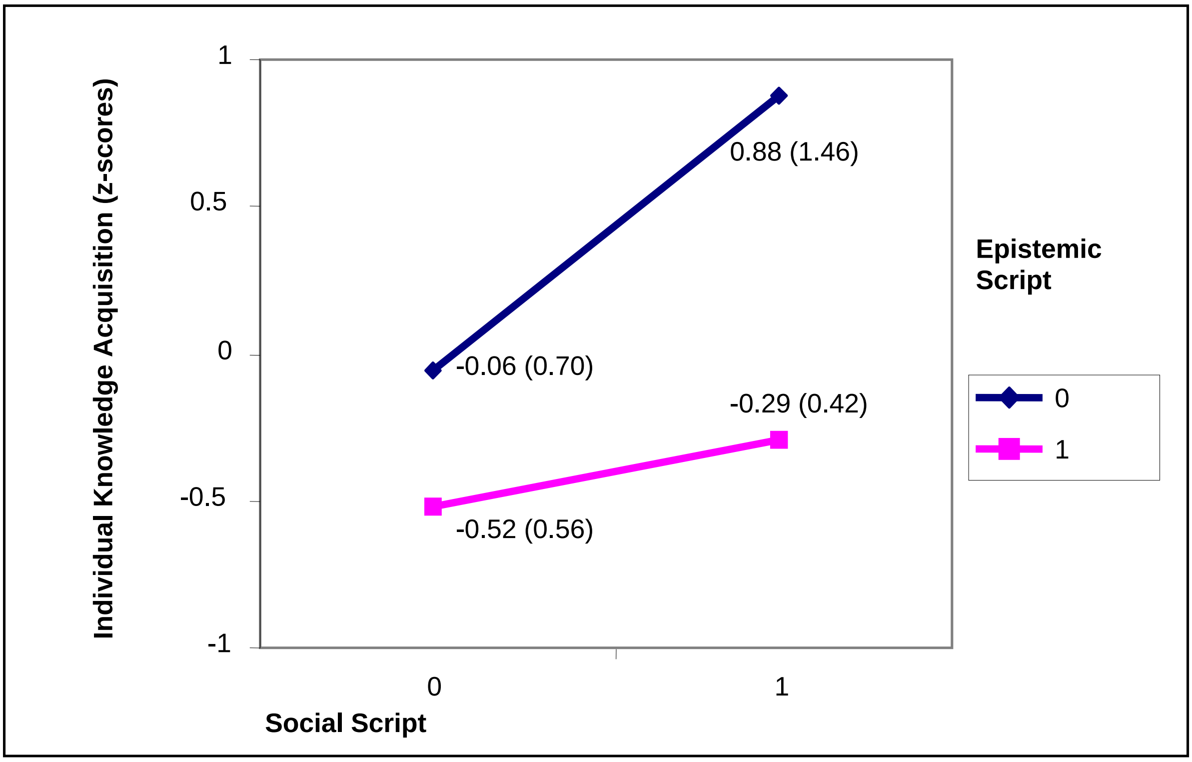
Table 3: Epistemic script prompts of study 2.

Theory	*Empirical Findings*
What are the most important concepts of the theory?	How was the theory examined?
What are the main ideas of the theory?	What were the results of the empirical studies?
Consequences	*Individual Judgment*
Which pedagogical interventions can be concluded from the theory?	What do I like/dislike about the theory?
Which limits of pedagogical interventions can be concluded from the theory?	Which of my own experiences support/do not support the theory?

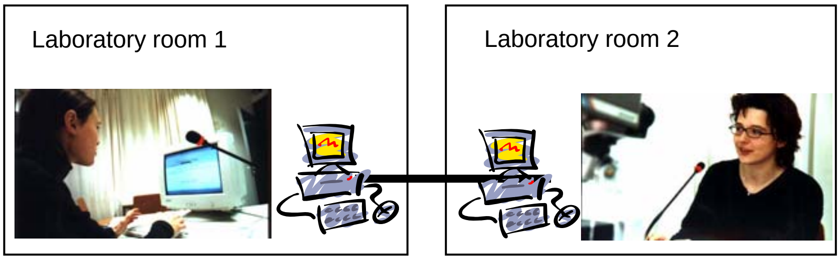
Table 4: Social script sequences and learning activities of study 2.

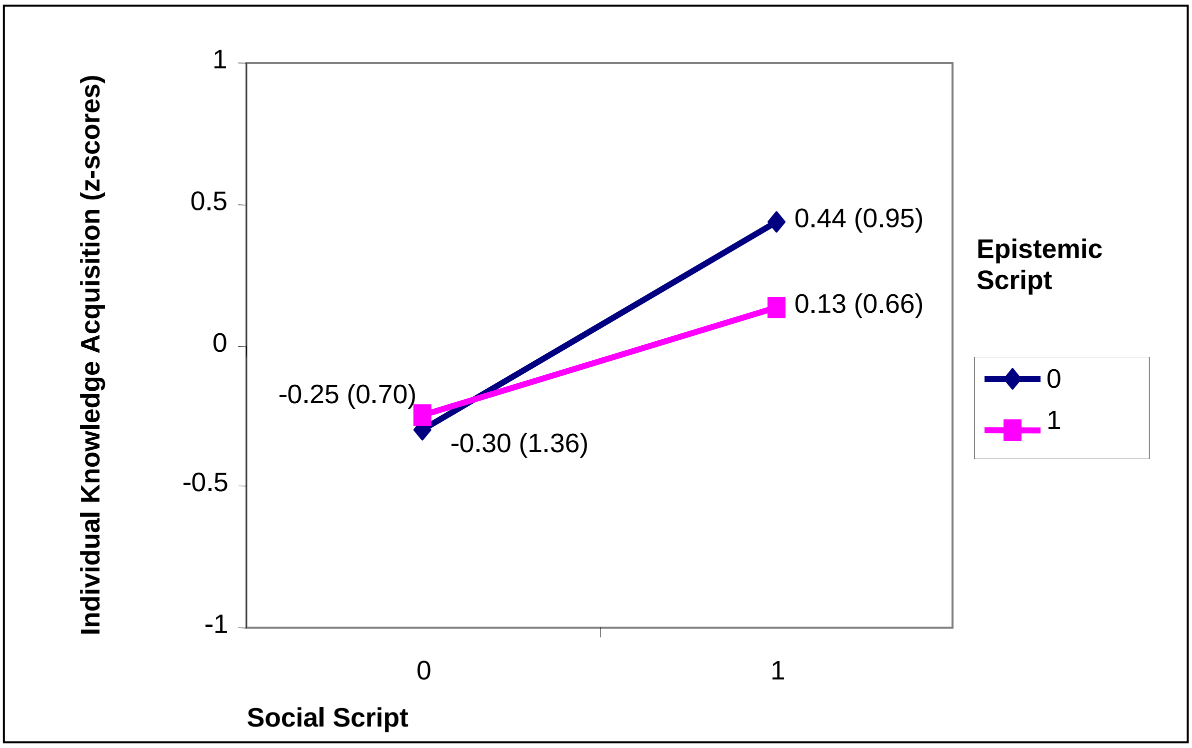
	Tutor	Tutee
Step 1	Explaining the text material	Asking comprehension questions
Step 2	Supporting the learner's activities	Explaining and typing the information received in the shared text document
Step 3	Elaborating on text information individually	
Step 4	Discussing generated ideas with the partner	Discussing generated ideas with the partner and writing the results in the shared text document


Laboratory room 1
Laboratory room 2
Laboratory room 3
Task information and timer
Case information
Learning environment orientation map
Script prompts



Individual Knowledge Acquisition (z-scores)
1
0.5
0
-0.5
-1
0.88 (1.46)
-0.06 (0.70)
-0.29 (0.42)
-0.52 (0.56)
0
1
Social Script
Epistemic Script
0
1


Laboratory room 1
Laboratory room 2



Individual Knowledge Acquisition (z-scores)
1
0.5
0
-0.5
-1
0
1
Social Script
0.44 (0.95)
0.13 (0.66)
-0.25 (0.70)
-0.30 (1.36)
Epistemic Script
0
1