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Collaboration Scripts – A Conceptual Analysis

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Abstract

This article presents a conceptual analysis of collaboration scripts used in face-to-face and computer-mediated collaborative learning. Collaboration scripts are scaffolds that aim to improve collaboration through structuring the interactive processes between two or more learning partners. Collaboration scripts consist of at least five components: (a) learning objectives, (b) type of activities, (c) sequencing, (d) role distribution, and (e) type of representation. These components serve as a basis for comparing prototypical collaboration script approaches for face-to-face vs. computer-mediated learning. As our analysis reveals, collaboration scripts for face-to-face learning often focus on supporting collaborators to engage in activities that are specifically related to individual knowledge acquisition. Scripts for computer-mediated collaboration are typically concerned with facilitating communicative-coordinative processes that occur among group members. The two research lines can be consolidated to facilitate the design of collaboration scripts which both support participation and coordination and induce learning activities closely related to individual knowledge acquisition and metacognition. However, research on collaboration scripts needs to consider the learners' internal collaboration scripts as a further determinant of collaboration behavior. The article closes with the presentation of a conceptual framework incorporating both external and internal collaboration scripts.

Keywords:

computer-supported collaborative learning, scripts, collaboration scripts, scaffolding.

Introduction

Research on collaborative learning has repeatedly demonstrated that learners often do not collaborate well spontaneously (Cohen, 1994). For example, they tend not to participate equally (Cohen and Lotan, 1995), often engage only in low-level argumentation (Bell, 2004), and rarely converge on a comparable level of knowledge acquisition (Fischer et al., 2002). There is a need for instructional support that guarantees a higher quality of both collaborative learning processes and individual learning outcomes. Such instructional support has been described and analyzed more systematically as scaffolding (e.g., Quintana et al., 2004; Pea, 2004; Reiser, 2004; Sherin et al., 2004; Tabak, 2004). Derived from the Vygotskyan concept of the Zone of Proximal Development (Vygotsky, 1992), scaffolding is seen as a way to support learners as they accomplish tasks that they would not be able to accomplish on their own (Wood et al., 1976). Originally addressing parent-child interactions, the term scaffolding has also been used to describe artifact-based instructional support (e.g., Quintana et al., 2004). With respect to collaborative learning, at least two classes of scaffolds can be distinguished: (a) scaffolds that provide support on a conceptual level and (b) scaffolds that provide support concerning the interactive processes between the collaborators. Scaffolds providing learners with conceptual support concerning the contents of the task at hand are, for example, questions or prompts that guide learners in discussing a specific aspect of a physics problem (“What is the relationship between force and motion?”; “If ball A hits ball B with the speed of X, what is the resulting speed of ball B?”). Scaffolds structuring the interactive processes of collaborative learning shape collaboration through a specification of different roles and associated activities to be carried out by the collaborators. For example, learners are asked to explain the contents of a text and to critique contributions of their learning partners at specific points in the learning process.

Especially in research on computer-supported collaborative learning (CSCL), such scaffolds have been called collaboration scripts (e.g., Dillenbourg, 2002; Rummel and Spada, 2005; Weinberger et al., 2005), and describe an instance of socio-cognitive structuring (Ertl et al., in press).

Collaboration scripts have been used to structure both face-to-face (e.g., O'Donnell and Dansereau, 1992; Palincsar and Brown, 1984) and computer-mediated collaboration (e.g., Dillenbourg, 2002; Rummel and Spada, 2005; Weinberger et al., 2005). However, given the variety of existing collaboration script approaches, the term lacks conceptual precision. In this article, we analyze systematically previous research on collaboration scripts. We first work towards a definition of collaboration scripts by identifying central conceptual components that are more or less shared among different approaches. We then compare prototypical collaboration script approaches used for either face-to-face or computer-mediated learning on the basis of these conceptual components to detect commonalities, differences, and deficits of the two research lines. Based on the identified deficits, we develop a conceptual framework that describes how collaborators and collaboration scripts interact in collaboration tasks. We believe that this framework can be used to inform both the design of collaboration script approaches and future theory building, and trigger subsequent empirical research on collaboration scripts.

To sum up, the article focuses on the following questions:

(1) What are the central conceptual components of collaboration scripts?

(2) Based on these components, what are the commonalities and differences between collaboration scripts developed for face-to-face and computer-mediated learning?

(3) What can be derived from this comparison with respect to design, theory building, and empirical research on collaboration scripts?

Central Conceptual Components of Collaboration Scripts

To answer research question 1 concerning the central conceptual components of collaboration scripts, we start by examining the original meaning of the term script in cognitive psychology. Schank and Abelson (1977) used the term to refer to culturally shared knowledge about the world that provides information about conditions, processes, and consequences of particular everyday situations. In this perspective, scripts consist of a number of variables (or slots) for persons or objects playing prominent roles in such situations. A script provides individuals with knowledge about how these variables function within the course of action represented in the particular script. Furthermore, the script provides the individual with information about appropriate actions within the particular situation and helps participants better understand the everyday situations they are involved in. This results in enhanced information processing and in a reduced need for coordination between the actors. Schank and Abelson (1977) explain the meaning of scripts by offering the ”restaurant script” as an example. This script specifies that the guest enters the restaurant, signals the waiter, says he would like to see the menu, chooses one item from it, waits for the meal to be brought to his table, etc. Using this script, a recipient is able to understand short information sequences like “Martin went to a restaurant and ate a beef steak”. By possessing the adequate culturally shared script and knowing its implications, the recipient has the knowledge necessary to fill in any gaps in the information sequence. In the case of the restaurant script, the recipient is therefore able to conclude that Martin entered the restaurant, signaled the waiter to have a look at the menu, chose one menu item, namely the beef steak, ordered it, waited until it was prepared, etc.

Cognitive psychology typically views scripts as highly specific memory structures that remain relatively fixed in situations in which the script is activated. This is especially true for approaches which aim at developing computational models of cognitive systems that work in accordance with a prespecified script. For such models to function properly, the individual steps and activities of the script must be well defined and contain detailed rules (see Schank, 1999). For example, in the restaurant script, first taking a seat and then choosing a meal from a menu are activities that are constitutive for the activity “going to a restaurant” and are only alterable under exceptional circumstances (e.g., when all tables are occupied and guests have to wait on the bar). In contrast, collaboration scripts can vary in the degrees of freedom they attribute to learners to structure their collaboration. In a rather open version, they can provide a frame of reference in the form of a scenario (e.g., giving the global instruction to critique each others’ contribution) without giving further instruction about how the process of critiquing should look. Learners are then relatively free to choose and perform appropriate activities (for example re-read a text, ask thought-provoking questions, provide counterevidence, etc.). In scenarios using collaboration scripts that leave little freedom to the learners, individuals are severely constrained in the specific activities they can choose from and how they perform them (e.g., a computer-interface that demands a specific on-screen action be performed by one participant before displaying the next screen).

Although the usage of the term script diverges between cognitive psychology and educational psychology, several similarities can be detected which might help derive a preliminary definition of what collaboration scripts are. For example, both scripts used in cognitive psychology (which are viewed as individual cognitive structures) and educational psychology (which are known as collaboration scripts) pursue specific objectives. According to Schank and Abelson (1977), scripts enhance both understanding and recall (on an individual level; e.g., Nuthall, 2000) and promote the coordination of activities in a particular situation (on a group level). Similarly, collaboration scripts are goal-oriented in the sense that specific approaches help learners engage in smooth collaboration processes and reach specific (learning) objectives.

Furthermore, both cognitive scripts and collaboration scripts engage individuals in specific activities. In the restaurant script, these activities include entering the restaurant, waiting to be seated, following the waiter to a table etc. In collaboration script approaches, such activities might be summarizing, questioning or explaining. The detailedness of the script instructions can range from only naming the activities learners are supposed to show (e.g., “give an argument”) to the specification of single substeps of the activity (e.g., “give evidence”, “state a claim”, “give a reason” as substeps of developing an argument; see Kollar et al., 2005). Each of the imposed (sub-)activities can also be presented in a more or less structured way. Although some scripts provide learners with a lot of freedom for how to perform a specific activity, others do not. Activities should, however, be in accordance with the pre-defined objective of the script, regardless of whether they are broken down into scripted substeps and whether there are constraints on how the activities can be performed.

Sequencing also plays an analogous role in scripts from the perspectives of cognitive and educational psychology. In both cases, the sequence in the script does not only specify which activities learners should perform but also when they should perform them. In the restaurant script, the script provides actors with sequential knowledge about first entering the restaurant, followed by waiting to be seated (in the U.S. – but not in Europe!), following the waiter to a table, and so on. Collaboration scripts also specify or imply which activities collaborators should perform and in what order, for example, first reading a text and then summarizing it (see O’Donnell and Dansereau, 1992).

Cognitive scripts and collaboration scripts do not only specify when to perform a specific activity, but also who is supposed to perform the activity. The restaurant script specifies that the waiter brings the menu and the guest chooses a meal from it. Similarly, collaboration scripts distribute roles among the collaborating partners, for example, an explainer and a commentator role. Distributing collaboration roles helps support the collaborating partners in approaching the task from multiple perspectives. This, in turn, helps learners consider problems from various viewpoints (Spiro et al., 1991) and reduces the danger of acquiring inert knowledge (Renkl et al., 1996). In both cognitive and collaboration scripts, role distribution is however not always made explicit. Sometimes the activities that one participant is supposed to conduct define his or her role without explicitly naming this role. For example, playing a commentator role is automatically implied by having learners critique other learners' contributions.

There is another difference between cognitive scripts and collaborative scripts concerning the way the script contents are represented. Cognitive scripts are internal representations about courses of action in particular situations. Collaboration scripts are external representations that are presented textually (e.g., King, 1998), as graphical representations (Pfister and Mühlpfordt, 2002), or orally (e.g., Palincsar and Brown, 1984). Hence, collaboration script approaches can vary in the type of representation through which specific instructions are presented to the learners. There is evidence that different representations have differential effects on learning which may, in turn, interact with learner characteristics (e.g., Mayer, 2001; Plass et al., 1998).

In summary, a comparison between cognitive scripts and collaboration scripts reveals several parallels that can help define what collaboration scripts are. We identified five components as being pivotal for answering the first research question, "What are central conceptual components of collaboration scripts?". These components are: (1) learning objectives,

(2) type of learning activities, (3) sequencing of activities, (4) role distribution mechanisms, and (5) type of representation (see table 1). As a working definition, a collaboration script can be described as an instructional means that provides collaborators with instructions for task-related interactions, can be represented in different ways, and can be directed at specific learning objectives. These objectives can be reached by inducing different kinds and sequences of activities which are implicitly or explicitly clustered to collaboration roles. Scripted activities can be broken down into single acts that together form a larger activity, and scripts can vary with respect to how much structure they provide.

Having defined what we mean by the term collaboration script, we next review existing collaboration script approaches for face-to-face vs. computer-mediated learning by applying these five conceptual components (research question 2). By comparing approaches from these two research lines, we aim to identify areas of convergence and divergence between them to find areas in which both research lines can fruitfully inform each other concerning both an appropriate design of collaboration scripts and theory building. We further identify common research deficits that might inform future empirical research in the field.

INSERT TABLE 1 ABOUT HERE

Collaboration Scripts for Face-to-Face Learning

Over the last twenty years, research has documented ways to improve collaborative learning. In the following section, four prototypical collaboration script approaches developed for face-to-face learning are presented. The collaborative learning programs reviewed improve the interaction between collaboration partners and boost collaborative learning. All the approaches are empirically based or have triggered substantial subsequent research. They are germane to different group sizes – from dyads to whole classes. rThe approaches under consideration are Scripted Cooperation (e.g., O'Donnell and Dansereau, 1992), ASK to THINK – TEL WHY (e.g., King, 1997), Structured Academic Controversy (Johnson and Johnson, 1994), and Reciprocal Teaching (Palincsar and Brown, 1984).

Scripted Cooperation. This approach was developed by Angela O'Donnell and Donald Dansereau and their colleagues and triggered a large research agenda (for an overview see O'Donnell, 1999). Several variants of scripted cooperation were subsequently developed and empirically tested (e.g., Larson et al., 1985; O'Donnell et al., 1987; Rewey et al., 1992). The original MURDER-script (the acronym stands for "mood", "understand", "recall", "detect", "elaborate", "review" and describes its sequence) involves the interaction between two partners learning from a text. First, the experimenter or the learners themselves split the text up into paragraphs. Then, each learner reads the first passage individually. After that, the partners put the text aside and engage in different roles: One plays the recaller, whose task is to recall the text information as completely as possible. The other partner plays the listener and tries to detect and correct misconceptions and identify omissions. After that, the partners elaborate jointly on ways to make the text content more memorable. They can accomplish this by connecting the information with their own prior knowledge, e.g., by drawing comparisons or links to other topics. Once the dyad has worked through the first text passage in this manner, the next segment is read and roles are switched. The script instructions can be presented to the learners in different ways. Lambiotte et al. (1987) provided the instructions in written format after each text paragraph. Larson et al. (1984) did not provide learners with written instruction during collaboration but instead trained learners on the correct application of the script instructions prior to the actual collaborative learning phase. Hythecker et al. (1988) state that the usual training time is about one hour.

The objectives of the MURDER-script are twofold. First, learners are supposed to acquire knowledge about text content. Second, they are supposed to acquire text-learning strategies. These strategies include cognitive skills such as explaining and metacognitive skills such as monitoring. In accordance with these objectives, Scripted Cooperation increases learners' engagement in cognitive and metacognitive activities. As an example for cognitive activities, learners are supposed to engage in explaining. As an example for metacognitive activities, the collaboration script requires learners to engage in monitoring. To ensure that learners perform these activities effectively, they are often supposed to practice them first during a training phase. Sequencing of the activities is regulated by the different phases introduced in the MURDER-script. First, both partners have to read a text passage. Next, learner A summarizes the text and learner B tries to detect and correct misconceptions and identify omissions. Then, the learning partners elaborate on the text content to make it more memorable. Finally, they read the next paragraph. This sequence cannot be changed by the learners. The script also specifies and distributes collaboration roles. After having read a text passage, one learner has to play the recaller, while the other plays the listener. These roles are switched several times during the learning process. The representation type of the MURDER-script varies between empirical studies. In some instances, the instructions are presented and internalized before the actual collaboration phase so that the collaboration is guided by the learners' mental representations of the MURDER-script. In other studies, the instructions are written on the same sheets of paper that contain the text the learners are working on..

ASK to THINK – TEL WHY. Alison King worked extensively on methods for scaffolding collaboration, with a focus on supporting peer-questioning. She developed a peer-tutoring approach for classrooms to support knowledge construction in dyads or in larger groups of learners (King, 1997, 1998, 2002). The ASK to THINK - TEL WHY model distributes structured reciprocal tutoring roles (questioner vs. explainer) among the learners and attaches specific activities to these roles. These activities are initially introduced by the teacher, who models them in class before the learners apply them in their subsequent collaboration (the training time is about 160 minutes spread over four school lessons; King, 1997). There are three main groups of activities: (a) specific question types that the learner in the questioner role asks during collaboration (review questions, thinking questions, probing questions, hint questions, and self-monitoring questions), (b) elaborative explanations the learner in the explainer role creates in reacting to those questions (including answering the "why" and "how" of the question as well as establishing links to one's own and the partner's prior knowledge rather than merely describing objects), and (c) communicative skills such as listening attentively, providing sufficient thinking time, giving evaluative feedback, etc. After reading a text or listening to a class presentation, learners individually create and write down two review questions and two thinking questions. After that, the learning partners determine who plays the questioner and who plays the explainer first. The questioner then asks one review questions (e.g., "What does … mean?") to activate the explainer's knowledge about the topic at hand. If the explainer fails to answer the question, the questioner asks probing questions (e.g., "Tell me more about…") or hint questions (e.g., "Have you thought about…?"). If the review question is answered correctly, the questioner proceeds by asking thinking questions (e.g., "What do you think would happen to … if … happened?"). When appropriate, the questioner asks self-monitoring questions (metacognitive questions) that help the explainer make his or her learning process explicit and monitor it effectively. Throughout this process, learners are supposed to follow the communication rules mentioned above (giving appropriate thinking time, etc.). Learners are equipped with prompt cards that remind them to follow the sequence of question types. These prompt cards contain question starters for each question type and descriptions of what elaborated explanations are and what communication skills to follow during collaboration. After one complete cycle, the questioner and explainer roles are switched.

The objectives of the ASK to THINK – TEL WHY approach are to support learners in their acquisition and comprehension of information presented in texts or oral presentations as well as in developing the skills necessary to process the content. This includes cognitive skills, for example concerning asking questions, metacognitive skills, for example concerning monitoring, and communication skills, for example concerning giving enough thinking time. Accordingly, the activities can be grouped into cognitive, metacognitive, and communicative activities. In addition, these activities are explicitly sequenced: The learner in the questioner-role asks certain question types in a pre-specified order. The script further prescribes an explicit distribution of collaboration roles. It specifies that one of the collaborators plays the questioner while the other plays the explainer. A role switch is also included. With respect to the representation type, the model relies on (a) the teacher orally modeling the instructions (i.e., auditive representation) and (b) the prompt cards containing written reminders of the activity type (i.e., written representation).

Structured Academic Controversy. This method, developed by Johnson and Johnson (1994), involves groups consisting of four learners. Within these groups, dyads are created and assigned to opposing positions on a specific topic. The learning material is distributed between the two pairs and dyads are instructed to make any information in their own material available to the other dyad when it might support their position. Pairs then develop their position and present their arguments to the other dyad. During this presentation, learners exchange thoughts and information, possibly create counterarguments to the other dyad's arguments, discuss the rationale of their group's approach, etc. In this step, the discussion can be led relatively freely. However, the teacher encourages learners to abide by certain rules of constructive controversy learners are introduced to before collaboration. The listeners are instructed to listen to the arguments as carefully as possible since it is later on their task to support their counterdyad's position. In the next step, a role switch indicates that the two dyads must adopt and present the position they have just tried to rebut. After that, the positions are dropped and all four learners are instructed to seek a synthesis of their discussion by writing a joint position statement. This position is later to be presented to the class. Johnson and Johnson (1994) emphasize that a training on social and interpersonal skills should precede the controversy, including "confirming others' competence while disagreeing with their positions and challenging their reasoning (being critical of ideas, not people)" or "first bringing out all the ideas and facts supporting both sides (differentiating the differences between positions) and then trying to put them together in a way that makes sense (integration of ideas)" (p. 80). The teacher presents these instructions prior to collaboration and the learners practice them. The instructions also appear on the learners' instructional sheets that they have at their disposal during collaboration.

Structured Academic Controversy aims at two kinds of objectives, namely (a) to support learners in an acquisition of knowledge about the topic at hand and (b) in an acquisition of debating skills. Therefore, the script induces relevant cognitive and metacognitive learning activities. Cognitive activities include generating arguments, explaining arguments, and generating counterarguments. Metacognitive activities include taking the opposing perspective or paraphrasing what someone said if it is not clear. Structured academic controversy further prescribes sequences of the induced learning activities. Learners are informed about the different collaboration phases: the development and presentation of a position, discussing the presentation, reacting to counterarguments on that position, adopting the other dyad's position, and finding a synthesis. Within the individual steps, learners are free in how to carry these activities out since there is no further support on how to create arguments or how to rebut a position. The approach further distributes collaboration roles among the learners and gives instructions on what to do when adopting these roles. The script has one dyad present its position while the other dyad listens. Similarly, roles are distributed in subsequent phases. The script also specifies a role switch. Apart from naming the induced activities associated with these roles, there is no further support specifying how to act in these roles. The script's representation type includes an auditive representation of the teacher's oral presentation of the strategies prior to collaboration (which is followed by a training), and written reminders on the instructional materials that provide rough guidelines rather than specific steps and substeps.

Reciprocal Teaching. This approach, developed by Palincsar and Brown (1984), was designed to support reading comprehension of reading beginners and children with poor reading comprehension abilities. At the core of this approach are four reading strategies that the teacher introduces to the class. These strategies are questioning, clarifying, summarizing, and predicting. After the teacher has modeled the correct application of the strategies, learners are divided into small groups of variable size and work to apply the strategies when reading new text passages, thereby rotating the teacher role among them. The adult teacher then takes on a coaching role and, in the ideal case, eventually abandons the teaching role so that the learners can take it over. The four strategies form a broad framework in which discussion about the text takes place: At first, the student in the teacher role asks questions concerning the contents of the text. Next, the group discusses these questions and formulates further questions before the student in the teacher role summarizes the most essential parts of the text passage. If someone does not agree with that summary, all learners reread the passage and discuss the summaries until they have agreed upon one variant. After that, learners make predictions about the following text passage. The duration of the intervention can take several weeks.

The <u>objectives</u> of Reciprocal Teaching have both a cognitive and a metacognitive dimension: On the one hand, learners are supposed to be supported in comprehending text content. On the other hand, they are supposed to acquire comprehension-monitoring skills. Consequently, the induced <u>learning activities</u> are part cognitive and part metacognitive. Cognitive learning activities include questioning and clarifying; metacognitive activities include summarizing and predicting. Learning the correct application of these activities is an iterative process guided by the adult teacher, who is supposed to assuming a coaching function rather than to give detailed instructions on how the activities should be conducted. The activities are further performed in a specific <u>sequence</u>: First, the student in the teacher role is supposed to ask questions about the text, which are then clarified by the group. After that, learners generate a summary. At the end of a cycle, they make predictions about how the text continues. In addition, there is a sequencing aspect lying in the fact that the task of leading the discussion rotates between the learners. In this way, <u>collaboration roles</u> are distributed: At any time during collaboration, one learner plays the role of the discussion leader, while his or her co-learners stay in their natural pupil role. A role switch prescribes that each learner is supposed to play the discussion leader at least once. Concerning the <u>representation type</u> it appears that the script instructions are not always externally represented during collaboration. The teacher presents the learning activities and their sequence orally before collaboration via modeling and can re-introduce them whenever appropriate during collaboration. By applying the script the learners continuously internalize its contents..

Comparing Collaboration Scripts for Face-to-Face Learning

Although the selected approaches cover a variety of tasks, learning settings, and group sizes, they do exhibit certain commonalities. The presented approaches typically target two classes of objectives: cognitive objectives and metacognitive objectives. With respect to cognitive learning objectives, all approaches support learners in gaining knowledge about the text or task as well as in acquiring elaborative learning strategies such as questioning or explaining. The presented approaches have an additional focus on promoting the acquisition of metacognitive skills like monitoring, which can be considered higher order learning strategies (Rosenshine and Meister, 1994). Empirical research indicates that the interventions helped learners achieve their particular learning objectives (e.g., O'Donnell, 1999; King, 1998; Johnson and Johnson, 1994; Palincsar and Brown, 1984).

The presented approaches aim to promote different learning activities: For example, the MURDER-script has learners engage in activities such as summarizing or monitoring, whereas Johnson and Johnson's (1994) approach is more directed towards arguing and debating. From a more abstract perspective, the learning activities can be labeled as cognitive and/or metacognitive activities. However, there are differences with respect to how specific the instructions concerning these activities are. For example, the ASK to THINK – TEL WHY approach structures the activities on a rather detailed level by requiring learners to complete question prompts. Reciprocal Teaching gives rather general directives on how to engage successfully in clarifying, questioning, summarizing, and predicting. The activities induced in Structured Academic Controversy are rather implied than explicitly stated. By focusing on promoting learners to engage in elaborative and metacognitive activities, collaboration scripts for face-to-face learning tend to adopt an individual learner perspective: They are primarily concerned with augmenting the learning outcomes of each individual learner through participating in the collaborative learning experience. In other words, collaboration is primarily seen as a means to support individuals to acquire knowledge. Group-building and group-supporting processes such as communicating or coordinating are not in the primary focus of this perspective, though they are touched upon in ASK to THINK – TEL WHY, Structured Academic Controversy, and Reciprocal Teaching, for example by demanding learners to provide each other with enough thinking time.

With respect to their sequencing procedures, the four approaches are very specific. In Scripted Cooperation and ASK to THINK – TEL WHY, learners are provided with highly specific directives concerning when to engage in which learning activity. To a lower extent, this is also true for Reciprocal Teaching and Structured Academic Controversy. Reciprocal Teaching sequences the four learning strategies the whole class is supposed to employ, and Structured Academic Controversy puts four collaboration phases in a fixed order. However, the concrete activities learners are allowed to show in these phases are less strictly prescribed than it is the case in Scripted Cooperation and ASK to THINK – TEL WHY.

Concerning role distribution, there are fewer observable differences between the four approaches. They all regulate explicitly what roles are distributed between the learning partners. Moreover, all approaches include an explicit role switch to have each learner experience the benefits of each collaboration role and the associated learning activities. Reciprocal Teaching is the approach which gives learners the most freedom of choice regarding which role they want to engage in. The learners themselves decide whether they want to adopt the teacher’s role. In the other approaches, there is less opportunity for the learners to control their involvement in one or another role, since the scripts provide explicit regulations specifying that each learner must engage in each of the corresponding roles.

Concerning the representation type of the presented collaboration scripts, it is common for the specific instructions to be presented orally by a teacher or an experimenter and practiced by the learners before collaboration. These trainings can take up to several hours, as it is the case in Scripted Cooperation or Reciprocal Teaching. During the actual collaboration phase, collaboration scripts are either represented as written notes on a sheet of paper (e.g., prompt cards in ASK to THINK – TEL WHY), or are re-presented by the teacher repeating them occasionally (e.g., Reciprocal Teaching), or are not externally represented at all (once learners have internalized them well enough during preceding training sessions and the course of collaboration).

In conclusion, collaboration scripts developed for face-to-face learning focus on encouraging learners to engage in effective collaboration on an individual, cognitive-elaborative level. Learners are supposed to conduct higher-order activities such as generating elaborated explanations and asking thoughtful questions, for which they often receive highly specific support. Studies by Webb (1989) have shown that engaging in generating such explanations can significantly improve knowledge acquisition. The act of questioning leads to a check of learner's current understanding and ensures better learning of the text (Graesser and Person, 1994). Since collaboration scripts for face-to-face learning aim to foster such "high-level" (cognitive and metacognitive) learning (King, 1997), the merit of this research tradition lies in its ability to provide insights into the instructional design of what might be termed "learning enhancers": Features that increase the learning success of individual learners engaging in collaborative learning to levels they would not be able to reach without instructional support.

Collaboration scripts for face-to-face learning exhibit a tendency towards a highly specific structuring of collaborative learning processes to effectively foster individual learning. Scripts are often designed in a rather detailed manner, i.e., larger activities are often broken down into smaller substeps which are scripted themselves (e.g., asking questions in ASK TO THINK – TEL WHY is broken down into asking review questions, asking comprehension questions, asking hint questions, etc.). Furthermore, collaboration scripts used for face-to-face learning often (at least in the beginning before the script instructions are internalized by the learners) do not leave much freedom for the learners (a) to decide <u>which</u> activities to carry out at a particular point in time, and (b) <u>how</u> to conduct these activities. The script instructions' high specificity is often achieved by extensive trainings that precede actual collaboration and ensure that learners perform the activities correctly. The aim of highly structuring collaborative learning processes is to give learners affordances to engage in fruitful and to set constraints for engaging in suboptimal collaboration processes. As Dillenbourg (2002) describes, such highly specific instructions do, however, bear the danger of over-scripting. Over-scripting implies the occurrence of a significant loss of degrees of freedom and therefore may contradict the very nature of collaborative learning as an open, non-coercive endeavor. There seems to be a trade-off between effective structuring (effective in that it supports high-level cognitive and metacognitive processes) and over-scripting, which needs to be considered by designers of collaboration script approaches. The question of what is the optimum degree of structuredness of a collaboration script (e.g., for what types of learners in what kinds of contexts) is open to future research.

Collaboration Scripts for Computer-Mediated Learning

We now turn to an analysis of collaboration scripts developed for computer-mediated learning. Due to the dynamic development of networked computer technologies, a number of collaboration scripts for computer-mediated settings have been described over the last years, starting with the pioneering work of Scardmalia and colleagues on developing the CSILE-environment (Scardamalia et al., 1989; Scardamalia and Bereiter, 1991, Scardamalia and Bereiter, 1993/1994). Although the term collaboration script is currently high on the agenda of the research community on Computer-Supported Collaborative Learning (CSCL; e.g., Dillenbourg and Jermann, in press; Dönmez et al., 2005; Ertl et al., 2005; Kollar et al., 2005; Miao et al., 2005; Schellens et al., 2005; Weinberger et al., 2005), not all authors call their approaches collaboration scripts. The selected approaches we present in the following do, however, meet the criterion of supporting collaborative learning through encouraging specific collaboration processes. The selection of approaches reflects the variety of scripts that have been developed in this strand of research. The group size ranges from dyads of learners to a theoretically infinite number of learners. They also cover the most common synchronous and asynchronous communication media like chat tools and discussion boards. Further, all approaches are prominent in their field and underwent empirical research. As can be seen in table 2, the approaches considered in this article are the ones by Baker and Lund (1997), Hron et al. (1997), the Learning Protocol-approach by Pfister and Mühlpfordt (2002) and the CaMILE (Collaborative and Multimedia Interactive Learning Environment) approach by Guzdial and Turns (2000).

INSERT TABLE 2 ABOUT HERE

The approach by Baker and Lund (1997). This approach integrates a collaboration script into a text-based learning environment in which two learners communicate by aid of a chat tool and a shared physics diagram. The learners' task is to collaboratively create an energy chain model. Learners are provided with a real physical apparatus and a text presenting the main concepts of the problem. The communication interface includes a number of buttons containing short sentences or sentence starters to guide the learners' interaction. These buttons represent four groups of communicative acts. The first set of buttons deals with the construction of an energy chain in the shared diagram (e.g., "I think that…"), the second represents communicative acts with the aim of reaching an agreement ("OK"), the third is designed to manage the learners' interaction ("Where do we start?"), and the remaining buttons represent acts aiming at doing something else ("Read the handout!"). A mouse click on buttons with complete sentences ("Do you agree?") immediately makes the sentence visible on the partner's screen. A click on a button containing an incomplete sentence (prompt; for example "I think that…") causes it to be copied into the text-window on the learner's own screen. Then the learner is supposed to complete the sentence and send it to the shared chat window.

With respect to the five conceptual components introduced earlier, the collaboration script developed by Baker and Lund (1997) can be analyzed as follows. The approach has two main objectives. First, it is intended to enable learners to understand the energy concept by modeling energy flow behavior. A second objective is to help learners overcome communication problems associated with the characteristics of chat communication, such as incoherent text, missing nonverbal cues, etc. (Schwan, 1997; Fabos and Young, 1999). The activities the learners engage in are also two-fold. On the one hand, learners are supposed to engage in elaborative activities such as giving explanations (which is achieved through the provision of buttons like "I propose to…"). On the other hand, the tool leads learners to perform explicit coordination activities ("Do you agree?"; "Where do we start?" etc.). The approach does not explicitly prescribe a detailed sequence according to which to engage in these activities. However, the various button prompts provide an implicit method of sequencing. For example, beginning a sequence by clicking on the

“Do you agree?” button would not make sense. In contrast, “Where do we start?” is clearly supposed to be used at the beginning of collaboration. With respect to the distribution of collaboration roles, it appears that the approach does not explicitly demand the learners to take on roles. Rather, the learner’s preferences determine if and how they distribute roles, choose which activities are part of that role, and maintain or switch roles. With respect to the type of representation, the instructions are represented textually, namely in the inscriptions on the buttons.

The approach by Hron et al. (1997). Hron et al. (1997) developed a collaboration script that structures a dyad’s interaction within a text-based setting. Learners are provided with erroneous graphical diagrams from biology, which they are asked to correct using a graphical manipulation tool. First, one of the two learning partners receives a system message requesting an initial proposal for correcting the model. This first suggestion has to be formulated and typed into a text field and sent to the learning partner. By clicking on a button with the title “Do you agree?”, the learner is supposed to ask for an agreement from the learning partner. This causes a window to appear on the learning partner’s screen that displays a request for signaling agreement or disagreement. If the learner disagrees with the partner’s suggestion, he or she has to formulate a statement that outlines the reasons for this disagreement. The other learning partner is then asked to read this statement again and to signal agreement or disagreement. This discourse loop is repeated until an agreement on the partner’s suggestion is reached. After that, the diagram is released for further manipulation.

The approach of Hron et al. (1997) can be characterized as follows: The objectives of this collaboration script are firstly to help learners acquire domain-specific knowledge about a well-defined biology problem. Secondly, the collaboration script aims to facilitate coordination in text-based online communication. To reach these objectives, Hron et al. (1997) engage learners in higher-order activities such as explaining and commenting. Coordinative activities ("Do you agree?") also play a prominent role in this approach. With respect to explaining and commenting, the script instructions are not very detailed since they do not provide learners with specific requirements concerning how to create a good explanation or a fruitful comment. In contrast, the coordinative activity of asking for an agreement is highly structured, since the interface is blocked as long as learners do not come to an agreement. Sequencing of the learning activities is achieved by the interface design: It specifies that learners first have to suggest how to correct the structure of the diagram and then request their partner's agreement. Learners can hardly ignore this imposed sequence, since the interface does not allow for a deviation from these activities. Similarly, there is a rather explicit distribution of collaboration roles between the two learning partners, although roles are not explicitly labeled: One learner takes on a composer role and one takes on a commentator role. Learners are required to switch roles after the discourse loop is finished. The script's representation type can be characterized by its reliance on textually coded instructions. These instructions are partially located in the system messages that prompt learners to perform a specific activity and partially in the inscriptions of the prompt buttons. One distinctive characteristic of the script is that not all structuring features are visible and therefore externally represented. For example, turn taking is guided by the design of the communication interface so that only one learner can contribute to the discussion at any given time.

The Learning Protocol-approach by Pfister and Mühlpfordt (2002). Pfister and Mühlpfordt (2002) developed a collaboration script for a chat-based learning environment for groups ranging from three to five persons, including one tutor. The learners' task is to discuss topics from geology and philosophy. The communication interface provides three kinds of interaction-structuring methods: First, the interface requires learners to indicate explicitly which message they refer to. This is achieved by asking them to draw an arrow to the particular message or to a specific part of that message. Second, learners are supposed to specify what kind of message they are about to send to the shared chat window. To do this, a menu appears which includes a list of three possible statement types: question, explanation, and comment. Once the learners have made these first two selections, they are able to write a message and send it to the shared chat window. Third, the communication interface regulates the sequence according to which learners are supposed to send messages to the shared chat window. To this end, the system gives written information in a separate window about whose turn it is at each point in time and simultaneously blocks the other learning partners' interfaces. Usually, learners are supposed to send their messages in turn. If a learner categorizes a contribution as a question, the system automatically blocks all learners' chat windows and authorizes only the tutor to respond.

The objectives of the Learning Protocol-approach are (a) to relate key concepts from geology and philosophy by discussing them on the basis of introductory texts and (b) to alleviate coordination to achieve a more coherent discussion. Students engage in two basic types of activities: On the one hand, learners engage in higher-order activities such as questioning, explaining, and commenting. Learners must categorize their messages as a question, explanation, or comment. However, they are not provided with information on how to compose a relevant question, explanation, or comment. Beneath those cognitive-elaborative activities, learners also are supposed to engage in coordinative activities, for example by drawing arrows from their message to the message they want to refer to. Sequencing is achieved by requiring learners to take turns in making their contributions except when a question is asked to the tutor. Despite this sequencing, learners are still free to choose when to compose which of the three possible message types. Though collaboration roles are not explicitly defined, the range of possible roles is restricted to a questioner, an explainer, and a commentator role. However, these roles are not explicitly labeled, and learners are not told when to engage in which role. The script's representation type includes different codes: The script contains written information about who is supposed to compose a message at any given point in time. Also, the list of the three possible message types is presented textually. A graphical code (arrow) is used to make the reference to other messages explicit. The interface is designed to specify which group member has to send a message and when. This is achieved by simultaneously blocking the other group members' chat windows. However, this component of the approach is neither explicitly stated nor externally visible for the learners.

CaMILE (Guzdial and Turns, 2000). Guzdial and Turns (2000) developed a collaboration script approach for discussion forums, in which a principally infinite number of learners can participate. The system operates on three design principles. First, to achieve a high level of transparency, it contains specific discussion management features. For example, within each thread, the system displays the type (e.g., "new idea", "rebuttal"), author, and date of origin for each message. Second, CaMILE provides certain facilitation features. For example, before typing a note, learners have to specify what type of message they want to create. They can choose between five alternatives: new idea, rebuttal, revision, comment, and question. They can also select whether they want to have one of several prompts be pasted into their note for further support (e.g., "I propose to…"). Third, CaMILE contains so-called anchoring features, which address the problem of low participation in online discussion forums. An anchor can be any page on the Web that is of interest to the learners, when a particular note in CaMILE includes a link to that page.This link can be installed by the instructor or by a learner. That note then represents the beginning (or anchor) of a new discussion thread. For example, a teacher may create a web page containing provocative theses on abortion. By adding a link to the discussion forum, this web page automatically becomes the anchor of a new thread. Every participant who clicks on that link is then directed to the discussion forum.

Concerning the outcomes of collaborative learning, the objectives of the CaMILE approach are not pre-specified. The teacher can lead the discussion in multiple directions, although the scripts' structure implies that teachers will mainly use the system to support the learners' acquisition of domain-specific knowledge. The main process-related objective is to achieve a more coherent discussion by including instructions that encourage learners to focus on a specific topic. The activities supported by CaMILE revolve around elaborative strategies such as explaining, rebutting, or questioning. A distinctive feature is that the learners can choose to paste prompts into their message to support its composition. If a learner decides to do so, the system's support becomes more structured with respect to the chosen activity. With respect to sequencing, CaMILE does not include any features prescribing when to compose what type of message – or even to compose a message at all. Since the script provides the learners with a list of prescribed learning activities, it implicitly triggers an engagement in either a composer or a commentator-like collaboration role. The same is true with respect to switching collaboration roles, which is not explicitly prescribed but left to the discretion of the learners. With respect to the script's representation type, the script instructions are provided in a textual format. However, the teacher using the script can give further script instructions, possibly in a graphical or an oral format.

Comparing Collaboration Scripts for Computer-Mediated Learning

As it was the case for the face-to-face approaches analyzed above, several commonalities in the design of collaboration scripts for computer-mediated learning can be identified. With regard to their objectives, the presented approaches focus on fostering the acquisition of the domain-specific knowledge about the learning material. In the approach by Baker and Lund (1997), for example, learners are expected to acquire knowledge about the energy concept, whereas Hron et al. (1997) focus on helping learners acquire knowledge about the biological problem at hand. All the approaches also strongly emphasize achieving smooth communication and coordination among the learners. In the Learning Protocol-approach, for example, this is achieved by designing the communication interface in a way that it controls turn taking. In CaMILE, communication and coordination are supported by demanding learners to label each contribution as a new comment, question, or rebuttal.

Each of the presented approaches aims at supporting slightly different types of activities. In general, two categories of learning activities can be identified: (a) cognitive-elaborative activities (e.g., explaining, commenting) and (b) communicative-coordinative activities (e.g., requesting agreement). However, in all the presented approaches for computer-mediated learning, the script instructions focus more heavily on communication, being very specific with respect to each learner's involvement. Hron et al. (1997) require that the learners request their partner's agreement to their own activities. Baker and Lund (1997) provide effective communication acts to keep the workflow going. Pfister and Mühlpfordt (2002) are more concerned with promoting higher-order learning activities like explaining and commenting (as compared to the other three approaches), but they also focus on helping learners overcome the limitations associated with chat-based communication. Due to their focus on supporting communication and coordination, the approaches predominately support group processes, i.e., processes that occur on a social rather than on an individual level. Individual learning processes are implicitly treated as a consequence of smooth communication and coordination. As an exception, the CaMILE approach focuses more heavily on engaging the individual learner in cognitive-elaborative activities, offering support for the activities like explaining or commenting. Yet, by allowing learners to decide whether to paste prompts into their messages, learners can circumvent this support. In the Learning Protocol-approach, learners are supposed to provide explanations, but are not told what a good explanation is. The script does not provide learners with guidance on how to carry the activities out in a way that would relate more closely to individual knowledge construction. Learners may indeed engage more in giving explanations – but presumably only learners with high explanation abilities will benefit, whereas learners with lower abilities may fail to create good explanations. Thus, collaboration scripts for computer-mediated learning tend not to be as specific with respect to higher-order, cognitive-elaborative learning activities as compared to communicative-coordinative activities.

The sequencing of particular learning activities is achieved differently in each of the approaches. The script developed by Baker and Lund (1997) provides a large degree of flexibility concerning when to carry out specific learning activities. The learners basically decide for themselves when to engage in one of the activities. Similarly, the scripts developed by Pfister and Mühlpfordt (2002) and Guzdial and Turns (2000) do not provide learners with clear guidance on when to engage in a particular activity, since learners have the opportunity to choose when they want to generate a specific type of message. The cues presented in the different script approaches do however sometimes implicitly trigger certain action sequences. It can be assumed that providing learners with collaboration scripts that allow for certain degrees of freedom will trigger internal action sequences that guide further collaboration among the learning partners. In contrast, Hron et al. (1997) provide learners with rather explicit guidance concerning the sequence of activities they have to perform. The design of the communication interface stipulates that learners always take turns in giving suggestions or providing feedback to their partner's utterances.

With respect to role distribution, the analysis shows that some scripts for computer-mediated learning provide clearer specification than others. For example, in the Learning Protocol-approach, collaboration roles and the related learning activities are rather explicit (at least in their labels), even though learners are free to choose one of the three induced collaboration roles. However, the communication interface does hardly allow for any activities different from the ones that are presented as possible message types. In a similar way, this is also true for the script provided by Hron et al. (1997). In contrast, Baker and Lund's (1997) approach does not assign learners to specific collaboration roles. They can choose and design their roles without being bound to them for a whole learning phase. Similarly, CaMILE allows learners to choose freely whether they want to engage in a composer role to create a new idea, or whether they want to act as a commentator and provide a comment on a learning partner's idea. In the approach by Baker and Lund (1997) and in CaMILE, the learners decide for themselves whether to adopt and perform a collaboration role.

The representation type of collaboration scripts for computer-mediated learning is different in each of the presented approaches, but may also vary within one particular approach. For example, the Learning Protocol-approach uses different formats: The design of the communication interface requests that learners label their contributions as explanation, comment, or question. Learners are required to select the appropriate type from a written list represented in an applet-window. In contrast, the learners' task of indicating which message they wish to refer to is represented in a graphical format (in the form of arrows). The third script component, sequencing, is represented textually in a separate window. The other three approaches rely mostly on textual representation of the script instructions. In the Hron et al. (1997) approach, the interface specifies textually at each point in time which learning partner is supposed to engage in a particular activity. CaMILE and the approach presented by Baker and Lund (1997) also rely on textual representations for each of their specific collaboration script components. Some of the presented approaches are characterized by the fact that some script components are not visible or otherwise directly perceivable for the learners, since they are realized as part of the interface design. For example, in the approach by Hron et al. (1997), sequencing is not externally represented by a list specifying whose learner's turn it is. Instead, the system simply blocks the chat window of the learner who is not supposed to write a contribution in the shared chat window.

In conclusion, the most apparent commonality of the presented collaboration scripts for computer-mediated learning is that they strive to support learners in acting effectively in a computer-based learning scenario on a communicative-coordinative level. With respect to these communicative-coordinative processes, the scripts can be very specific (as for example in the Hron et al. approach). Due to the challenges related to the particular characteristics of the communication medium, focussing on supporting communication and coordination seems necessary because impeded communication and coordination can make effective learning impossible. Research on collaboration scripts for computer-mediated learning therefore provides significant insights into the instructional design of what might be termed the interactional essentials of collaborative learning: Features of the learning environment that guarantee that the basic interactional requirements for effective collaborative learning processes are met.

Furthermore, some collaboration scripts for computer-mediated learning do not consider detailed instructions for higher-order learning processes as a major determinant of successful collaboration. Quite often, these approaches provide learners with lots of freedom concerning how to engage in higher-order activities, with the script instructions being rather unspecific in this respect. Providing rather open collaboration scripts might be adequate for learners who already know how to engage effectively in collaborative learning situations. Problems may arise when learners lack or hold only inadequate knowledge about how to formulate a good explanation, for example. A lack of collaboration abilities might result in a deficient repertoire of effective collaboration strategies, causing learners to make inefficient use of the freedom provided by the collaboration script. These learners then are likely to fail to reach the desired learning objectives. Against this background, we claim that collaboration scripts for computer-mediated learning should provide learners also with more detailed support concerning how to engage in higher-order learning activities (Rosenshine and Meister, 1994) that are more closely related to individual knowledge acquisition. Initial steps in this direction have however already been taken in the selected approaches: For example, the activities in CaMILE (such as analyzing and commenting) are activities that can be viewed as leading to higher order learning gains, such as acquiring elaborative and metacognitive skills. However, Guzdial and Turns (2000) concede that the provision of the specific cues in CaMILE “does not, in itself, mean that learning is going on” (p. 441). This indicates that further, more specific instructional support might help. Similarly, the other three approaches remain unclear concerning the question how learning activities, their sequence, the type of representation and further features of the presented collaboration scripts relate to higher-order learning gains.

Concerning the type of representation, it appears that collaboration scripts for computer-mediated settings often are designed rather intuitively. Although all of the approaches presented have been designed innovatively and creatively, there is often a lack of a theoretically and empirically guided analysis on how the respective script features should be represented during the learning process. There is a significant amount of literature about how learners process different forms of external representations and how these affect learning (e.g., Mayer, 2001; Schnotz, 2002; Suthers and Hundhausen, 2003; Vekiri, 2002). This research was mainly conducted with individual learners but should be considered more seriously by developers of collaboration scripts for computer-mediated learning to avoid problems for learning stemming from bad interface design. One real advantage of research on collaboration scripts for computer-mediated learning, however, is that, by exploiting the potential of programming new communication tools, scripts can be imposed without even making them explicit to the learners. In a face-to-face setting this would hardly be possible. By reducing the amount of instruction, it is likely that learners will experience less cognitive load and have more cognitive resources available to elaborate content information (Sweller et al., 1998). This is likely to yield more desirable learning outcomes than when learners have to struggle to understand the externally represented instructions they are provided with.

What Can Research on Collaboration Scripts for Face-to-face and Computer-Mediated Settings Learn from Each Other?

Our comparison of collaboration script approaches for face-to-face and computer-mediated learning on the five conceptual components introduced at the beginning of this article reveals commonalities and differences as well as strengths and weaknesses of the two research lines. Both research lines can learn from each other to accumulate knowledge about how to design powerful collaboration scripts for various group sizes, tasks, communication media, and learning settings. However, not all problems in one research line are mirrored by strengths in the other. Instead, there are also shared deficits. In this section, we delineate commonalities and differences between the two research lines as well as deficits that are shared by both of them.

Concerning their objectives, collaboration scripts designed for both settings have a strong cognitive focus, e.g., on learning text contents or solving problems. In all approaches for face-to-face learning under examination, there was an additional focus on metacognitive objectives, such as acquiring monitoring strategies. Collaboration scripts for computer-mediated learning, in contrast, often exhibit smooth communication and coordination between the collaborators as a second objective. To date, neither of the two research lines has dealt extensively with developing approaches to foster motivational or emotional variables. This is unfortunate since there are already empirical studies indicating that motivation can suffer when learners are provided with very detailed collaboration scripts (e.g., Kollar, 2001).

Both collaboration scripts for face-to-face and computer-mediated learning aim to facilitate cognitive and metacognitive activities such as explaining, questioning, or commenting. Yet, the ways in which these activities are typically introduced differs between the two research lines. In approaches for computer-mediated learning, activities are often only mentioned so that learners perform them without further instructions. In approaches for face-to-face learning, collaboration scripts tend to provide additional guidance (either through training or written support) concerning how to engage in these activities. Collaboration scripts for computer-mediated learning additionally exhibit a focus on communicative and coordinative activities. This focus is rooted in the different communication characteristics between face-to-face and particular computer-mediated forms of communication. Computer-mediated collaboration often requires more explicit coordination efforts, since nonverbal cues or other opportunities for coordination are limited (e.g., Dillon and Gabbard, 1998; O'Connaill and Whittaker, 1997). Consequently, script instructions concerning communicative-coordinative acts often are highly specific in collaboration scripts for computer-mediated learning.

The sequencing of activities in collaboration script approaches for face-to-face learning is often realized explicitly, i.e., learners receive clear instructions concerning when to engage in an activity. These instructions are introduced by training and often reinforced during collaboration by the teacher or by external artifacts such as prompt cards. In approaches for computer-mediated learning, sequencing is often left up to the learners. Yet, the communication interface often suggests an implicit sequence for the activities to be performed, e.g., by providing learners with prompts that only make sense when they are used at a particular point in time. Another design strategy in approaches for computer-mediated learning is to realize sequencing subliminally through a specific communication interface design that, for example, blocks all chat windows except the window of the particular learning partner who is supposed to make a contribution. In this way, an integral component of collaboration scripts is not made explicit to the learner. This might free up resources for on-topic discussion and subsequent content-related learning.

Role distribution, in many collaboration scripts for face-to-face learning, is often realized very explicitly so that the scripts provide detailed instructions concerning which learner has to act in which role at what specific point in time. In contrast, approaches for computer-mediated learning tend to distribute collaboration roles in a rather implicit manner. The actual design of the communication interface may however suggest the specific roles learners are supposed to perform. For example, offering certain sentence starters by aid of which a learner can generate explanations automatically implies to take on an explainer as opposed to a questioner role.

Concerning the representation type, most approaches for face-to-face learning use textual (e.g., prompt cards) and auditive representations (e.g., the teacher explaining the specific instructions). However, most of the script instructions are represented mentally, since learners are supposed to internalize them before collaboration. In collaboration script approaches for computer-mediated learning, instructions are often represented textually or graphically. In some cases, the interface is designed to only allow for one specific activity or sequence to be carried out without actually representing that script component externally.

As we have argued, collaboration scripts for computer-mediated learning typically focus on facilitating communicative and coordinative processes, representing processes that are located at the intersubjective level: Through focusing on communication and coordination, the primary targets of the script instructions are the interactions between the group members rather than the cognitive processes of each individual learner. That way, research on collaboration scripts for computer-mediated learning generates knowledge about how to design computer-supported collaborative learning environments that enable learners to interact smoothly with each other. This is what we have called knowledge about the interactional essentials of collaborative learning. Research on collaboration scripts for face-to-face learning, on the other hand, rather focuses on supporting learners in engaging in elaborative activities which are more closely related to individual knowledge acquisition. That way, this strand of research generates knowledge about how to design scripts that enable learners to deeply elaborate learning materials. This is what we have called knowledge about learning enhancers of collaborative learning. When these different foci are recognized, it can be claimed that future collaboration script approaches can benefit when insights from the two research lines come together in collaboration script design. This could result in a development of approaches that guarantee smooth communication and coordination as well as higher-order individual learning.

The two research lines' different foci on the group and the individual learner as the primary target of instruction are also reflected on a theoretical level. Authors of collaboration script approaches for face-to-face learning often refer to cognitive learning theories and information-processing models that regard knowledge construction as a process in which an individual's cognitive system integrates new incoming information with pre-existing knowledge structures in long-term memory. In contrast, research on collaboration scripts for computer-mediated learning often refers to sociocultural (Vygotsky, 1978) and situated theories (e.g., Lave and Wenger, 1991) of cognition. These emphasize the importance of participating in social practices in a community of learners and maintain that collaborative learning environments should be designed to support and guarantee this kind of participation. The acts of supporting participation in group activities (as it is done in many collaboration script approaches for computer-mediated learning) and enhancing individual cognitive processes (as it is done in many collaboration script approaches for face-to-face learning) do however not contradict each another. Both objectives can be reached by a well-designed collaboration script that supports each of these four poles (group vs. individual and communication vs. elaboration). However, designing a collaboration script that accounts for all of these aspects is a complex endeavor. One way to approach this problem is to provide learners with multiple scripts directed at supporting different objectives and activities. Yet, there is a danger of providing learners with too much instruction as well as with possibly incorrect instruction. Over-scripting might prove more detrimental for some learners than for others. For example, adults might have developed patterns of collaboration that are highly specific and useful for specific situations. Overlaying them is likely to produce reactance (Brehm, 1966) and motivation loss (Kollar, 2001). For adult learners, one solution could be to design collaboration scripts which leave them more freedom and allow them to rely on their own experiences and strategies to structure their collaboration processes.

In relation to this, research has not yet focused on the question of how structured a collaboration script should be to pursue its specific learning objectives. Similarly to Dillenbourg (2002), Cohen (1994) points to the dangers of micro-structuring processes of collaborative learning especially in sophisticated tasks that require creative problem solutions. In such tasks, highly structured collaboration scripts can reduce learners' degrees of freedom so much that high-level discourse can not take place. Further, it can be assumed that different groups or types of learners require differently structured collaboration scripts. Due to relevant learner variables, some learners might learn better with highly structured collaboration scripts, whereas others might require more open collaboration scripts. But which learner-related variables are most influential for determining the optimum degree of structuredness of a collaboration script? Research has consistently demonstrated that one of the most important predictors of individual learning is domain-specific prior knowledge (Dochy et al., 1999). Thus, it can be expected that learners differing in the level of domain-specific prior knowledge might benefit from differently structured collaboration scripts. In addition, it is reasonable to assume that the success of collaborative learning will also be strongly affected by learners' domain-general prior knowledge that guides them in how to act in a collaborative setting. Research needs to focus on discovering what knowledge on collaboration individuals bring to a collaborative learning situation and whether an externally provided collaboration script has the potential to activate adequate knowledge or compensate for deficient knowledge. We view this interplay of individuals' prior knowledge about collaboration and externally provided collaboration scripts as a core question for both the design of collaboration scripts and future theory building. Therefore, we address this issue by developing a conceptual framework on learning with collaboration scripts that is presented in the last section of this article.

A Person-Plus Framework of Collaboration Scripts: Future Directions for Theory Building and Empirical Research

Although research on collaboration scripts originally derived the term script from cognitive psychology (Schank and Abelson, 1977), most researchers departed from the individualistic notion of scripts as internal memory structures. Maybe as a consequence, research on collaboration scripts for face-to-face and for computer-mediated learning has largely neglected the importance of the individual and his or her procedural knowledge that guides behavior in collaborative situations. Especially in collaboration script approaches that are low structured and leave learners many degrees of freedom, effective collaboration strongly depends on how the learning partners themselves structure their collaboration. According to Schank and Abelson (1977), individuals develop internal knowledge structures or scripts through repeated participation in particular situations. These structures or scripts guide them in how to act in and understand these situations. Applied to collaborative learning, cognitive scripts about how to engage in collaboration develop as an individual repeatedly engages in collaborative situations, probably already beginning in early childhood. This knowledge may be termed "internal scripts on collaboration" or "internal collaboration scripts". It can be argued that this kind of knowledge is one central determinant of how collaborative learning proceeds, and that it stands in a complex relationship with externally provided collaboration scripts (see Carmien et al., in press).

To conceptualize the interplay between internal and external collaboration scripts, valuable ideas can be derived from theoretical approaches on distributed cognition (e.g., Derry et al., 1998; Hewitt and Scardamalia, 1998; King, 1998; Lebeau, 1998; Moore and Rocklin, 1998; Pea, 1993; Perkins, 1993; Salomon, 1993). Especially Perkins' (1993) person-plus-surround concept can be used as a basis for a conceptual framework incorporating the interplay of internal and external collaboration scripts in collaboration tasks. Perkins (1993) distinguishes between the person-solo and the person-solo, which both are involved when an individual is asked to solve a task in conjunction with other persons and/or an external artifact (e.g., a collaboration script). The person-solo describes the individual as one component of the system. The person-plus describes the whole system that comprises both the individual as well as his or her social and artifactual surround. In this way, cognition or “intelligence” (Pea, 1993) is viewed as being distributed between or spread over individuals and artifacts, thereby challenging the traditional cognitive stance that knowledge and intelligence is solely represented “within the head” of an individual (cf. Anderson, 2000). Although the notion of distributed cognition that Perkins (1993) advocates is not without criticism (e.g., Moore and Rocklin, 1998; Newell, 1990), it can serve as a heuristic for conceptualizing the interplay between internal and external collaboration scripts.

When accepting the notion that knowledge can be distributed between a person-solo and the surround, it can be asked where the knowledge necessary for task accomplishment actually is located – in the cognitive system of the individual or in the surround. For Perkins (1993), however, this question is only secondary. More important are the access characteristics of that knowledge, i.e. how easily this knowledge is accessible for the person-plus system (access characteristics; Perkins, 1993). For the system’s task performance, no qualitative difference is assumed when the necessary task-relevant knowledge is located in the person-solo or in the surround. What for Perkins is more important than the question concerning the location of task-relevant knowledge within the person-plus-system is the question what system component has metacognitive control over the system (executive function; Perkins, 1993). This can be done by either the person-solo (e.g., a learner who sets learning goals and monitors his or her individual progress and the group process) or the surround (e.g., an external collaboration script setting rules and goals and monitors their accomplishment). In yet other cases, it might be that the surround supports the individual in adopting the executive function over the system, having the effect that both internal and external scripts contribute to the controlling of the system.

Perkins' (1993) conception is helpful to understand how groups of learners engage in collaboration tasks, because it includes both the individual learners and their specific knowledge about collaboration and external support systems such as collaboration scripts as significant contributors to the collaborative activity (see also King, 1998). By adopting a person-plus view, the previous components of our analysis can be expanded by terms originating from a model of distributed cognition (e.g., accessibility of knowledge; executive function). As a result, it is possible to define a conceptual framework that takes the contributions of internal and external collaboration scripts in collaboration tasks into account. This framework (table 3) can be useful for an integration of previous research on collaborative learning with collaboration scripts and might stimulate more cumulative future research on the topic.

INSERT TABLE 3 ABOUT HERE

To develop a person-plus framework of learning with collaboration scripts, it is useful to at first determine the main factors involved when a group of learners tries to accomplish a collaboration task. On a very general level, at least three factors can be distinguished: (a) a global collaborative activity (or a set of global activities) the system needs to perform to solve the task, (b) knowledge about collaboration that is required to conduct these activities, and (c) the system's executive function that sets the goals and monitors the processes of collaboration. When mapping the five conceptual components of collaboration scripts identified earlier onto these three main factors, the following picture of collaboration can be drawn: The activity learners are engaged in can firstly be described in terms of the main objective that is tried to be pursued through its performance. For example, as in the approach by Baker and Lund (1997), the activity's objective might be to collaboratively construct a model of energy flow. The whole activity might then be broken down into several <u>sub-activities</u> (comparable to the type of activities-dimension introduced earlier) that are needed to pursue that goal. In the Baker and Lund script, these activities include "give a proposal to change the energy chain model", or "ask for your partner's agreement". These activities might be supposed to occur in a specific <u>sequence</u>. Applied to the Baker and Lund script, it might make sense at the outset of activity to provide a proposal on how to change the current model. Then the learner can ask his or her learning partner if the proposal is acceptable and change the model accordingly, etc. In addition, the sub-activities might be attached to <u>collaboration roles</u> such as a problem-solver and a commentator role.

The <u>knowledge</u> dimension should include at least two sub-categories. First, knowledge about how to act in collaboration tasks can be characterized by the <u>representation type</u>, which was the fifth conceptual script component introduced earlier. While regarding internal and external collaboration scripts as basically equivalent in their potential for guiding collaborative processes, the <u>type of representation</u> can include different mental as well as graphical, oral, or written representations. For example, a learner may hold a mental representation of collaboration that specifies to first discuss how to approach the task. In another case, instructions on a sheet of paper may explicitly state how the learning partners should act to pursue the goal of collaboration. Perkins' (1993) person-plus-perspective suggests that knowledge about collaboration can also be characterized with respect to its <u>accessibility characteristics</u>. Accessibility is presumably a central determinant of successful task accomplishment. If the knowledge about collaboration that is required to solve the collaboration task is not accessible in either the internal or the external collaboration script, a system consisting of two or more individuals and an external collaboration script will fail to accomplish the collaboration task. If the knowledge is represented in the external collaboration script, learners can use it to guide their activities which hopefully results in the group successfully solving the collaboration task. If one of the collaborators has the required knowledge accessible in his or her internal script, this knowledge might be translated more quickly into adequate collaborative action.

With respect to the executive function, the question is (a) how the planning and control of goal setting and (b) the planning and control of performance is realized. Goal setting planning and control can be made an explicit component of an external collaboration script ("Create an energy chain model!"). Goal setting may also be less specified in the external collaboration script and be transferred to the learners themselves (e.g., when learners are given the opportunity to set their own goals, such as "Choose a hypothesis you would like to defend in class"). Performance planning and control can similarly be either specific or more open. In this respect, the Hron et al. approach, for example, can be regarded as rather specific because the modeling window is blocked as long as partners do not find an agreement upon the next solution step. Reciprocal Teaching, in contrast, can be regarded as rather open with respect to performance planning and control. For example, the teacher asks learners to be aware of specific communication skills which in the end are largely subject to the learners' internal collaboration scripts.

Potentials of a Person-Plus Perspective on Collaboration Scripts

What are the potentials of a person-plus framework on learning with collaboration scripts? First, when acknowledging that collaborative learning processes are partially guided by internal scripts, partially by external scripts, and partially by their interaction, the resulting framework can help define differences between existing collaboration script approaches more clearly. We assume that specific aspects of interactions between learners like their sequencing behavior or their engagement in particular activities is a function of the interplay between their internal scripts and the external collaboration script. For example, CaMILE induces sub-activities like generating a new idea or commenting on an existing idea in a very explicit manner by providing learners with a limited selection of possible message types they can choose from.This means that sub-activities are largely being determined by the external collaboration script. In contrast, on the sequencing dimension, CaMILE provides learners with a great deal of freedom to decide when to engage in which sub-activities. That way, on the sequencing dimension, collaboration in a CaMILE scenario can be viewed as largely being driven by the learners' internal collaboration scripts. As another example, the ASK to THINK – TEL WHY script specifies in detail what sub-activities to engage in. In contrast, performance control depends on the teacher or on the learners themselves. Relating different collaboration script approaches to the dimensions of the framework might support a more thorough interpretation of the often inconsistent findings concerning the effects of external collaboration scripts. One outcome could be that external collaboration scripts that strongly guide the learners' sub-activities are only effective for specific types of learners, whereas a detailed prescription of specific sequences is not conducive to meeting their learning objectives.

Second, the framework can be used as a guideline for designing external collaboration script approaches. By explicitly acknowledging the importance of learners' internal collaboration scripts, it sharpens designers' senses to think thoroughly about the actual users who will work with the collaboration script and what the specific needs of this group might be. This calls for the need to develop instruments to assess learners' internal collaboration scripts to come to wellgrounded conclusions concerning what kind of support the learners need and to design external collaboration scripts accordingly.

Third, the framework can provide an opportunity to concert research efforts in the field more effectively. As the variety of collaboration script approaches presented in this article shows, research on collaboration scripts is very diverse, which makes it hard to integrate the different results obtained in the numerous empirical studies on the topic. With the framework that is presented here, it might be easier to identify open and pressing research questions that can be systematically approached than when such a framework is absent. In our view, one of the most important research needs relates to the question how and what collaboration script information should be distributed between the person-solo and the surround (see King, 1998). According to Perkins (1993), knowledge about higher-level processes should be kept in the person-solo (e.g., create arguments), whereas lower-level processes can be shifted to the surround (e.g., performing an addition by using a hand calculator). Instructions concerning low-level operations like “Now click on the OK-button” or “Wait until the diagram is released for further manipulation” might neither be part of the learners’ internal scripts nor be a relevant objective for internalization. On the other hand, at certain stages of the collaboration, it might be beneficial to omit certain aspects of the external script. One can assume that learners, through interaction with the external script, develop and constantly refine knowledge about how to structure their collaboration, thereby gradually integrating procedures represented in the external collaboration script into their internal scripts.

Finally, future research should address and investigate the dynamics of the interplay between internal and external collaboration scripts (Kollar et al., 2005). There are at least three different patterns of how internal and external collaboration scripts might interact. One possibility is that external collaboration scripts superimpose and replace internal scripts, thereby making them ineffective. This might be the case when an external collaboration leaves only few degrees of freedom and when it does not allow for any task procedures other than the ones intended by its designer. A second possibility is that external and internal collaboration scripts have additive effects so that external scripts trigger existing internal collaboration scripts that would not be activated without external support. That way, a system including scripts located in the person-solos and the surround would be superior to a system in which learners only have their person-solo collaboration scripts available. A third possibility is that there are interactive effects between internal and external collaboration scripts. It is reasonable to assume that as learners interact more and more with external collaboration scripts, a gradual internalization of script contents takes place. This requires a constant readjustment and reduction of the external collaboration script's specificity to ensure that learners are not given instruction they actually do not need. The process of reducing the amount of external instruction is known as fading. There are several approaches to fading from different theoretical perspectives (e.g., Collins et al., 1989; Lee, 2003; Leutner 2000; McNeill et al., 2004; Pea, 2004; Renkl et al, 2004), but these have not yet been given appropriate levels of consideration in research on collaboration scripts. Effective fading requires sophisticated methods for online assessment. The group's interaction patterns must be assessed to obtain a clear picture of which portions of the external collaboration script should be faded out when learners' are diagnosed as having internalized them. In CSCL environments, this could be increasingly achieved through language analysis tools implemented in the system that record the learners' interaction and use these data to adjust the structuredness of an external collaboration script accordingly. Dönmez et al. (2005) showed that after some training, algorithms developed in the field of applied linguistics are already able to analyze online discussions on a specific topic with reliabilities comparable to independent human coders. Adaptive external scripts could be developed if the results of these automated analyses were fed back into the design of the external collaboration script. The findings would then lead to fading specific components in or out as appropriate. In face-to-face learning, this assessment has always been the task of the teacher and is based on his or her observations of a group's learning processes. For classroom settings, using computer-supported online knowledge assessment techniques as developed by Dönmez et al. (2005) might be a promising way to support teachers in their evaluatory efforts as well as in decisions about the structure of the collaboration script required by a specific group. This way, collaboration scripts provided by a computer and scripts provided by a teacher can work together to provide an optimum support for collaborating groups – an instance Tabak (2004) calls synergistic scaffolding.

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Table 1

Central conceptual components of collaboration scripts.

Central conceptual components of collaboration scripts
Learning objectives
Type of activities
Sequencing features
Role distribution
Type of representation

Table 2

Collaboration script approaches for face-to-face vs. computer-learning included in the analysis.

Learning setting	Approaches included in the analysis
Face-to-face	O'Donnell and Dansereau (1992)
	King (1997)
	Johnson and Johnson (1994)
	Palincsar and Brown (1984)
Computer-mediated	Baker and Lund (1997)
	Hron, Hesse, Reinhard and Picard (1997)
	Pfister and Mühlpfordt (2002)
	Guzdial and Turns (2000)

Table 3

Main factors and subcategories involved in a collaborative learning group solving a task.

Main factor	Subcategories
Activity	Objective of activity
	Type of sub-activities
	Sequencing of sub-activities
	Collaboration roles
Knowledge	Type of representation
	Accessibility characteristics
Executive function	Goal setting control
	Performance control