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Toward a Script Theory of Guidance

in Computer-Supported Collaborative Learning

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Toward a Script Theory of Guidance in Computer-Supported Collaborative Learning

Abstract

This article presents an outline of a script theory of guidance for computer-supported collaborative learning (CSCL). With its four types of components of internal and external scripts (play, scene, role, and scriptlet) and seven principles, this theory addresses the question how CSCL practices are shaped by dynamically re-configured internal collaboration scripts of the participating learners. Furthermore, it explains how internal collaboration scripts develop through participation in CSCL practices. It emphasizes the importance of active application of subject matter knowledge in CSCL practices, and it prioritizes transactive over non-transactive forms of knowledge application in order to facilitate learning. Further, the theory explains how external collaboration scripts modify CSCL practices and how they influence the development of internal collaboration scripts. The principles specify an optimal scaffolding level for external collaboration scripts and allow for the formulation of hypotheses about the fading of external collaboration scripts. Finally, the article points towards conceptual challenges and future research questions.

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Toward a Script Theory of Guidance in Computer-Supported Collaborative Learning

The reasons for using collaborative learning as a mode of instruction are manifold. From a cognitive perspective (e.g., King, 1997), performing activities that seem to occur naturally in collaborative learning situations, such as giving explanations or asking questions, are assumed to change participants' cognitive structures. Approaches based on socio-cultural theory suggest that through participation in collaborative learning, individuals can gradually internalize collaborative practices as collaboration skills and cognitive strategies that may be useful in other settings as well (e.g., Kolodner, 2007). However, as research on collaborative learning has repeatedly shown, learners typically do not engage in these "high-level" collaboration processes without guidance (e.g., Weinberger, Stegmann, Fischer, & Mandl, 2007). Thus, a crucial question for research is how collaborative learning can be supported in order to stimulate such high-level collaboration processes and learning outcomes. Computer-supported collaborative learning (CSCL) allows for new learning experiences that many students have not encountered before. For example, web-based inquiry learning in the classroom (Linn & Slotta, 2000), online discussions of cases (Weinberger, Ertl, Fischer & Mandl, 2005), or joint writing and editing of wikis (Cress & Kimmerle, 2008) all aim at the collaborative construction of knowledge. However, the more a CSCL practice differs from traditional teaching and learning experiences, the more difficult it may be for students to collaborate efficiently. Students with little prior experience regarding these collaborative practices may not have developed adequate knowledge that guide them in collaborating in these settings. Following Kollar, Fischer, and Slotta (2007), we call this kind of knowledge "internal collaboration scripts". In the script theory of guidance in CSCL presented in this article, they play a crucial role in explaining what guides learners' activities in CSCL settings.

One way to compensate for lacking or non-functional internal collaboration scripts is to provide collaborators with *external* collaboration scripts (King, 2007; Kollar, Fischer, & Hesse, 2006; Rummel & Spada, 2005; Weinberger et al., 2005) that guide individuals in a collaborative situation. Despite some descriptive analytical accounts of what CSCL scripts are (e.g., Kobbe, Weinberger, Dillenbourg, et al., 2007) and a substantial number of empirical studies on the effects of external collaboration scripts on processes and outcomes of learning (e.g., Hämäläinen, Oksanen & Häkkinen, 2008; Rummel & Spada, 2005; Schellens, van Keer, De Wever & Valcke, 2007; Stegmann, Weinberger, & Fischer, 2007), a coherent theoretical account (i.e., a script theory) still appears to be missing. The goal of this article is to outline a script theory of guidance in CSCL to provide such a coherent theoretical account. Concerning the guidance of learners' activities in CSCL settings, the theory assigns a central role to two main factors, *internal* and *external collaboration scripts;* these are conceived of as distinct but largely parallel in structure. An *internal collaboration script* is a configuration of knowledge components about a collaborative practice and its parts at different levels of complexity (the so-called internal collaboration script components) that guide the person's understanding of and actions in the collaboration. It is assumed that this configuration is built up dynamically from its constituents during a particular instance of collaboration. An *external collaboration script* is a configuration of representations (e. g. textual or graphical) of a collaborative practice and its parts at (potentially) different levels of complexity (the so-called external collaboration script components). The external collaboration script is presented to a group of learners by an external source (e.g., a teacher or a website interface) as a means to guide their collaborative activities. It is assumed that this guidance emerges as a consequence of the way in which these external

representations influence collaborators' configuration of internal collaboration script components.

The script theory of guidance is based on four script components and seven principles. The seven principles, presented in Table 1, are grouped in subsets according to three questions:

1. How do internal collaboration scripts and situational characteristics interact in shaping CSCL practices (principles 1 & 2)?
2. How do internal collaboration scripts develop and change through participation in CSCL practices, and what is their role in the acquisition of knowledge (principles 3 - 5)?
3. How do external collaboration scripts affect CSCL practices and individual knowledge acquisition (principles 6 & 7)?

The four components are play, scene, role and scriptlet, and they are introduced with the first set of principles.

Table 1. Principles of the Script Theory of Guidance in Computer-Supported Collaborative Learning

Principle no.	Principle name	Principle formulation
(1)	Internal script guidance principle	When participating in a CSCL practice, the learner's understanding of and acting in this situation is guided by dynamically configured and re-configured internal collaboration scripts consisting of play, scene, scriptlet, and role components.
(2)	Internal script configuration principle	How an internal collaboration script is dynamically configured by a learner from the available components to guide the processing of a given situation, is influenced by the learner's set of goals and by perceived situational characteristics.
(3)	Internal script induction principle	If a learner participates in an initially unfamiliar CSCL practice, then he or she builds a new configuration of already available internal script components and, through repeated application of this configuration of internal script components, develops new higher-level components (play, scene, or role) that organize the subordinate components (scenes, roles and scriptlets) for this CSCL practice.

(4)	Internal script reconfiguration principle	If a learner's employed internal collaboration script (i.e., a configuration of internal script components) does not lead to understanding or successful actions in a CSCL practice, the internal collaboration script configuration is likely to be modified.
(5)	Transactivity principle	The more a given CSCL practice requires the transactive application of knowledge, the better this knowledge is learned through participation in this CSCL practice.
(6)	External script guidance principle	External collaboration scripts enable learners to engage in an instance of a CSCL practice at a level beyond what they would be able to without an external collaboration script either by inhibiting the automated use of internal script components or by inducing the application of internal script components that are not yet organized by a specific higher-level script component.
(7)	Optimal external scripting level principle	An external collaboration script is most effective for knowledge acquisition if it is directed at the highest possible hierarchical level of internal collaboration script components for which subordinate components are already available to the learner.

The script theory of guidance in CSCL draws on two main theoretical perspectives. *First*, it refers to schema-theoretical accounts of cognition, mainly to explain how internal scripts develop and how they are used for understanding and acting when collaborating with others. The script concept has had a long history in cognitive science, starting with the idea of quite large and stable (some say: rigid) cognitive structures (Schank & Abelson, 1977) to more recent approaches that have broken scripts down to multiple components of a dynamic memory that are flexibly combined on the basis of aspects of a situation and an individual's goals (e.g., Kintsch, 1998; Schank, 1999). The script theory of guidance builds on one of these more flexible schema theories, namely the theory of dynamic memory (Schank, 1999). *Second*, the script theory of guidance builds on socio-cultural perspectives, adopting the view that discourse activities on the social plane precede and shape the structure of complex cognitive skills (i.e., the Genetic Law of Development, Vygotsky, 1978). The theory also incorporates the idea of the Zone of Proximal Development (ZPD, Vygotsky, 1978), in particular the assumption that individuals advance their knowledge and skills by participating in activities that extend beyond their current skill level while being supported by more knowledgeable others. In the script theory of guidance, socio-cultural ideas are mainly used to explain how participation in CSCL practices stimulates (but not determines) the development of an individual's cognition (Kolodner, 2007). A main criticism of socio-cultural approaches has been the lack of assumptions about how the internalized knowledge is structured and selected in later discourse activities. By integrating socio-cultural accounts with assumptions of recent schema theory, the script theory of guidance addresses these criticisms. A further criticism of socio-cultural approaches has been that the process of internalization remains underspecified. To this end, the script theory of guidance specifies (a) how internal collaboration scripts are induced and reconfigured through participation in CSCL

practices and (b) how external collaboration scripts could be designed and gradually faded out to facilitate the development of internal collaboration scripts.

In the presentation of the theory principles, empirical findings are presented whenever possible as illustrations and initial support. Of course, most of the cited studies originally offered alternative theoretical accounts. However, the script theory of guidance provides a unified theoretical perspective to explain a broad range of findings from the CSCL literature. Yet, the corpus of presented studies cannot be considered a definitive empirical test of the assumptions of the script theory of guidance.

How Internal Collaboration Scripts Shape CSCL Practices

The script theory of guidance in CSCL includes two principles concerning how internal collaboration scripts affect CSCL practices and how they are selected (Table 1): (1) *When participating in a CSCL practice, the learner's understanding of and acting in this situation is guided by dynamically configured and re-configured internal collaboration scripts consisting of play, scene, scriptlet, and role components* (principle 1*, internal script guidance principle*). (2) *How an internal collaboration script is dynamically configured by a learner from the available components to guide the processing of a given situation, is influenced by the learner's set of goals and by perceived situational characteristics* (principle 2*, internal script configuration principle*).

CSCL practices are verbal and non-verbal interaction patterns of two or more participants that repeatedly occur in technology-enhanced settings with similar functions. We call knowledge of such a collaborative practice an "internal collaboration script" and regard them as configurations of knowledge components about a collaborative practice. The closeness of the

script term to the theatre context is intentional and has been emphasized earlier (e.g. by Schank, 1999). However, in differentiating the components of internal collaboration scripts and their flexible hierarchical organisation, we extend dynamic memory theory (Schank, 1999) by more explicitly integrating and characterizing a *role* component. Furthermore, we extend the theatre metaphor by replacing the "memory organization package" or MOP that Schank (1999) suggested as a top-level component, with a *play* component to emphasize partial parallelism between internal and external collaboration scripts that will be discussed below. According to our theory, knowledge about a collaborative practice thus comprises the following *components*: (1) The *play* component constitutes knowledge about the "play" that the participants are performing (e.g., an argumentative dialogue or joint Wiki writing), which includes knowledge of the sequence of scenes and of the roles involved in it. (2) *Scene* components include knowledge about situations in a play (Schank, 1999, p. 123). For example, within an argumentative dialogue play, a scene would be the development of a counter-position to a claim that was put forward before. (3) *Scriptlet* components constitute knowledge of sequences of activities within particular scenes (Schank, 1999, p. 125). For example, when developing a counter-position to an aforementioned argument, a learner's internal script may include scriptlets suggesting to first state a claim and then provide evidence for it. (4) *Role* components constitute knowledge of roles that are part of the current collaborative practice and organize appropriate activities that can be contributed by specific participants. As in a theatre play, roles typically extend across several scenes and comprise several activities. The role component thereby intersects with the scene component in organizing scriptlets that refer to these single activities. In the argumentative dialogue play, for example, the role component includes knowledge about the existence of at least two different positions that are advocated by at least two different persons who act in a

different, but rather compatible way (by exchanging arguments) across the different scenes of the play.

We argue that it would be a mistake to regard internal collaboration scripts as fixed cognitive structures that guide an individual through a complete collaborative practice. Instead, internal collaboration scripts are viewed as flexible in the sense that for almost any given situation, a learner will have a set of different plays, scenes, scriptlets and roles available that are likely to be (subjectively) applicable. Slight changes in the situation may evoke an on-the-fly exchange of some of the script components applied in this particular situation. Thus, internal collaboration scripts need to be understood as highly flexible configurations of knowledge components (plays, scenes, scriptlets and roles) that have a likely sequencing (if the collaborative practice proceeds as expected), but can be dynamically re-configured according to changes in the situation or in the activity. This is not necessarily a conscious process (Schank, 1999).

According to principle 1, an instantiation of a CSCL practice emerges as an interaction of the participating persons who are guided by their individual knowledge about the CSCL practice that is contained in their configurations of internal collaboration script components. According to principle 2, how internal collaboration script components available to a person are configured and re-configured as the guiding internal collaboration script depends on the person's goals and the perceived situational constraints and affordances that change as the collaborative practices evolves and transforms the situation. The guidance provided by the configuration of script components does not only relate to how people act in the situation, but also to how they understand the situation and what they therefore expect to happen.

Outside the CSCL context, evidence for the significance of internal scripts to understand and act in the world around us can be found in developmental psychology (e.g., Lampinen,

Faries, Neuschatz & Toglia, 2000) and psycholinguistics (Kellerman, Broetzman, Lim & Kitao, 1989). For example, Kellerman et al. (1989) asked university students to describe conversational activities that are typical for situations in which two persons meet each other for the first time. The researchers identified a culturally shared play (the "initial conversation MOP"; p. 27) that includes a set of scenes (initiation, maintenance and termination) which, in turn, include sets of scriptlets ("subroutines"; Kellerman et al., 1989, p. 50). These scenes and scriptlets also guided oarticipants in this study in their initial conversations with other participants.

Likewise, it can be assumed that internal collaboration scripts guide the way learners understand and act in *CSCL practices*. Empirical support comes from a study that examined the extent to which internal collaboration scripts affect the quality of collaborative argumentation in a CSCL inquiry unit (Kollar et al., 2007). Ninety secondary school students participated. Results indicated that students with more elaborate internal collaboration scripts about argumentation (measured by their performance in analyzing a discourse protocol) contributed more appropriate arguments to discussions than students with less elaborate internal collaboration scripts.

According to principle 2, situational *affordances* and *constraints* influence the configuration of internal collaboration script components. Affordances are perceived possibilities for activities in a given situation (see also Norman, 1993). For example, an empty text field with a blinking cursor is likely to be perceived as an opportunity to enter text via a keyboard. Constraints are perceived limitations on the set of possible activities. For example, if the collaboration interface of an online discussion forum automatically inserts "clarification question" into the subject line but provides a text entry window of only two lines when the reply button is clicked, then many other possible activities such as formulating an elaborate counter-argument seem to be excluded (see also Kirschner, Beers, Boshuizen, & Gijselaers, 2007).

Situational constraints and affordances can be specific for different kinds of external representations, and encountering a specific external representation can lead to the employment of corresponding internal collaboration script components. Evidence for this comes from a study by Suthers and Hundhausen (2003) in which 30 dyads of university students used either a graph, matrix, or text format to represent data, hypotheses, and evidential relations while exploring the causes of two science phenomena. Learners in the matrix conditions focused more strongly on the evidential relations in their verbal utterances than did learners in the other two conditions. This can be interpreted to mean that affordances to represent specific aspects of the problem influenced the participants' configuration of internal collaboration script components to guide them through the situation.

Beyond constraints and affordances of the situation, a person's goals also influence the selection of an internal collaboration script. Each configuration of internal collaboration script components that map onto the current goal structure of the person is more likely to be employed than any other configuration. Evidence for this can be found in a study by Pfister and Oehl (2009), in which 118 university students collaborated in small groups in a chat environment. They were told that they would either receive rewards based on their individual performance (individual goal focus) or that they would be rewarded based on their group's performance (group goal focus). In comparison to students with an individual goal focus, students with a group goal focus were better able to ground their discussion by using a function offered in the chat environment that used arrows to point to the text being referenced. . From a script theory of guidance perspective, imposing a group goal focus may have led to a different configuration of internal collaboration script components than imposing an individual goal focus, which was evident in improved grounding processes that were observed in the group goal focus condition.

Development of Internal Collaboration Scripts and Their Role in Knowledge Acquisition

Three further principles of the script theory of guidance address the internalization of collaboration scripts and their role in knowledge acquisition (Table 1): (3) *If a learner participates in an initially unfamiliar CSCL practice, then he or she builds a new configuration of already available internal script components and, through repeated application of this configuration of internal script components, develops new higher-level components (play, scene, or role) that organize the subordinate components (scenes, roles and scriptlets) for this CSCL practice* (principle 3*, internal script induction principle*). (4) *If a learner's employed internal collaboration script (i.e., a configuration of internal script components) does not lead to understanding or successful actions in a CSCL practice, the internal collaboration script configuration is likely to be modified* (principle 4*, internal script re-configuration principle*). (5) *The more a given CSCL practice requires the transactive application of knowledge, the better this knowledge is learned through participation in this CSCL practice* (principle 5, *transactivity principle*).

To illustrate these principles, suppose an individual encounters a situation in which collaborative activities are necessary that are not yet part of the individual's repertoire. This situation is likely to lead to confusion because the individual does not have available, for example, a play component that seems functional to guide understanding and action in the situation. However, the individual will not have entered the situation without internal collaboration script components about other collaborative practices that may share at least some aspects (e.g., scenes) with the present situation. Therefore, the individual will draw on a set of internal collaboration script components (i.e., scenes, roles, or scriptlets) that belong to other collaborative practices but fulfil comparable functions. According to the internal script induction

principle, if the same new configuration of such internal collaboration script components is employed in similar instantiations of the initially unfamiliar CSCL practice, a new play component will develop that combines formerly unconnected subordinate internal script components that have been successfully employed (see principle 3). The same applies to the formation of new scene or role components.

An application of components of other internal scripts is, however, only one way to deal with unfamiliar situations. If the individual experiences the selected internal collaboration script components as not leading to a satisfactory understanding or appropriate activities in an instance of a CSCL practice, an "expectation failure" (Schank, 1999, p. 41) occurs and a reconfiguration of the employed internal script components becomes more likely (see principle 4).

Empirical support for the internal script induction principle (principle 3) comes from a study by Rummel and Spada (2005) in which participants (N = 72) engaged in an unfamiliar CSCL practice (interdisciplinary work on patient cases between students of psychology and medicine) in a video-conferencing scenario. The results showed that mere observation of a model collaboration before collaboration led learners to acquire knowledge about how to collaborate in an unfamiliar CSCL practice. In terms of the internal script induction principle, it can be assumed that observing a role model led learners to select a set of previously unconnected internal collaboration script components, which helped them to effectively engage in a previously unfamiliar CSCL practice. The repeated participation in instances of this CSCL practice led to the development of a new play component that combined those previously unconnected internal script components.

A study by Kapur and Kinzer (2009) on productive failure offers preliminary support for the internal script re-configuration principle (principle 4). Science students ($N = 177$) learned

collaboratively with either well- or ill-structured problems. After collaboration, each participant solved a well- and an ill-structured problem individually. The results showed that during collaborative learning, learners failed to solve the ill-structured problems more often than the well-structured problems. However, in the individual ill-structured post-test, learners who failed during collaboration outperformed those who did not fail during collaboration. The authors argued that failure during collaboration enables learners to discern relevant features and structures. In terms of the internal script re-configuration principle, learners who experienced their selected internal collaboration scripts producing expectation failures during collaborative solving of ill-structured problems were more likely to reconfigure their internal collaboration script, thereby enabling them to better solve ensuing ill-structured problems.

There is ample evidence that learning is crucially influenced by feedback from the environment. It has to be noted, however, that learning does not automatically take place when learners are confronted with failure to understand and to act (e.g., Dole & Sinatra, 1998). The conditions of failure-induced re-configuration of internal collaboration scripts have not yet been investigated systematically, but one promising hypothesis is that failures have positive effects especially when they hinder individuals in reaching a personally relevant goal (Schank, 1999).

The transactivity principle (principle 5) states that the more a given CSCL practice requires the transactive application of knowledge, the better this knowledge is learned through participation. This principle is based on two main assumptions: The *first* assumption is that the more actively an individual applies certain knowledge, the better this knowledge is acquired.. For subject matter knowledge, Schank (1999) argued that without meaningful practices (typical for many non-problem-oriented, school-based learning environments) subject matter knowledge might be encapsulated in internal scripts that develop specifically for reproducing facts in exams.

However, this subject matter knowledge is likely to remain inert and can hardly be applied in contexts other than the exam (Renkl, Mandl, & Gruber, 1996). Support for this assumption comes from a study by Stegmann, Weinberger, and Fischer (2011) that examined the relation between the use of subject matter knowledge in an argumentative activity and individual subject matter knowledge acquisition. The authors analyzed 36 online discussions of groups of three students of Educational Science ($N = 108$). Their results showed that the more subject matter knowledge was applied to a problem case in the argumentative activity, the more knowledge was acquired by the participating individuals.

The *second* assumption of the transactivity principle is that individuals learn the more, the more a CSCL practice requires transactivity. A discourse is transactive when learners build on earlier contributions of their learning partner(s) and hence use their partner(s) as a resource. The transactivity assumption is a central tenet of collaborative learning research. Dillenbourg and Jermann (2007) suggest that the effectiveness of collaborative learning crucially depends on the necessity of mutual reference of the learning partners („Split Where Interaction Should Happen“; p. 292). According to Teasley (1997), *transactive* contributions are those in which an individual further develops a thought of another with „transacts“ such as integrations, critiques, clarifications, or paraphrases. In an empirical study ($N = 24$), Teasley found evidence for a positive correlation between transacts and learning outcomes during joint problem-solving. In a recent review, Chi (2009) showed that learning activities in which learning partners used one another as information resources and built on each others' thoughts were associated with better learning outcomes when compared to other types of activities. Similarly, Stegmann et al. (2011, see above) showed that discussions with higher transactivity resulted in more subject matter

knowledge being applied to a problem case and more knowledge acquired by the participating individuals, which can be interpreted as empirical evidence in support of this principle.

Effects of External Collaboration Scripts on CSCL Practices and Learning

External collaboration scripts are representations that may guide CSCL practices by either facilitating or inhibiting the application of internal collaboration script components of the participating individuals. In the *facilitation* case, an external collaboration script creates situational affordances that influence learners' selection of specific internal collaboration script components (according to principle 2) which are applied in the CSCL practice (according to principle 1). In the *inhibition* case, external collaboration scripts reduce the probability of dysfunctional internal script components being employed in the configuration that guides the learner. Inhibition works either by (a) interrupting automated sequences of script components by establishing situational constraints on the range of possible activities and making the learner aware of them through hints and prompts, or (b) creating incompatible affordances to engage the learner in sequences of activities that cannot be combined with the activities in the initially selected internal script.

The components of external collaboration scripts are assumed to largely correspond to the structure of the four types of components of an internal collaboration script described above. This does not imply, however, that the configuration of internal collaboration script components employed in a particular collaboration is a simple mirror image of the external collaboration script encountered in the learning environment. Rather, external collaboration script components are regarded as scaffolds that may induce a functional configuration of internal script components. The same scaffolds may stimulate different internal script configurations in learners

at different levels of expertise. The script theory of guidance differentiates between four types of scaffolds (or external script components) that differ in their cognitive target level: (1) *Play scaffolds* are prompts directed to influence the topmost level of an internal collaboration script configuration; that is, they provide general task definitions detailing the main goal of the collaboration such as joint problem solving or pro-con argumentation without giving further prompts on how to reach this goal. (2) *Scene scaffolds* target scenes already known by the individual (e.g., individual analysis, group discussion, plenary presentation) and put them into a sequence that constitutes a comprehensive play. (3) *Role scaffolds* target the application of knowledge on roles or role sets that can transgress the boundaries of scenes, and assign specific roles to the participating learners. (4) *Scriptlet scaffolds* prompt learners to apply available scriptlets needed to successfully engage in a scene.

The third set of principles addresses the effects of such external collaboration scripts on CSCL practices and on knowledge acquisition of the participating individuals (Table 1): (6) *External collaboration scripts enable learners to engage in an instance of a CSCL practice at a level beyond what they would be able to without an external collaboration script either by inhibiting the automated use of internal script components or by inducing the application of internal script components that are not yet organized by a specific higher-level script component* (principle 6, *external script guidance principle*). (7) *An external collaboration script is most effective for knowledge acquisition if it is directed at the highest possible hierarchical level of internal collaboration script components for which subordinate components are already available to the learner* (principle 7, *optimal external scripting level principle*).

Several empirical studies on the effects of external collaboration scripts on CSCL practices can be considered as supporting the external script guidance principle (principle 6; e.g.,

Hämäläinen et al., 2008; Kollar et al., 2007; Schellens et al., 2007; Schoonenboom, 2008; Stegmann, Weinberger, & Fischer, 2007; Weinberger, Stegmann, & Fischer, 2010; Wecker, Stegmann, et al., 2010; Weinberger et al., 2005). A first set of studies shows that external collaboration scripts can improve CSCL discourse, compared to unstructured CSCL. For example, Schoonenboom (2008) examined the effects of a collaboration script for grounding collaboration processes. Forty-two students worked together at a distance in small groups of four to six. The external collaboration script consisted of scene scaffolds to support grounding in a CSCL environment that instructed learners to first provide input individually, then discuss the contributions and finally build a consensus. Learners with the external collaboration script contributed more and were better able to share their knowledge and to identify knowledge differences than students without the external script. Hämäläinen et al. (2008) found similar positive effects of a collaboration script consisting of scene scaffolds in a study with vocational students.

Using an external collaboration script with role scaffolds, Schellens et al. (2007) distributed roles in an asynchronous discussion board which led individuals in small groups to engage in the intended, more role-congruent activities. The authors analyzed two successive cohorts of students ($N = 223$ and $N = 286$) participating in discussion groups for one semester with only the groups of one cohort being supported with an external collaboration script. Results showed that groups with an external collaboration script exhibited higher levels of knowledge building activities in the online discussions than groups without the script.

Stegmann, Wecker, Weinberger, and Fischer (2012) employed an external collaboration script aimed at supporting learners in online discussions to construct arguments on a scriptlet level with a claim, ground, and qualification. Learners were supported with an external script

that was implemented as a graphical interface offering different text fields labelled “claim”, “ground”, and “qualification”. The results of a study with 48 participants in groups of three showed that learners supported by scaffolding on the scriptlet level showed more cognitive elaboration during online discussion (measured by means of think-aloud protocols) and acquired more knowledge on argumentation than did learners without support.

The optimal external scripting level principle (principle 7) states that an external script that provides scaffolds for subordinate internal script components that are already available should be less efficient than one that directly targets higher-level internal script components because of the additional need to process unnecessary information. The idea of “over-scripting” (Dillenbourg, 2002) is related to this line of thinking. According to the script theory of guidance, over-scripting is not just *too much* external scaffolding. Over-scripting occurs when the provision of an external collaboration script inhibits the learner’s self-regulated application of appropriate higher-level internal collaboration script components (i.e., external scripting targeted at a wrong hierarchical level). . Therefore, an external collaboration script that includes unnecessary scaffolds at lower hierarchical script levels is likely to hinder knowledge acquisition.

A study by Mäkitalo, Weinberger, Häkkinen, Järvelä, and Fischer (2005) supports this assumption. Forty-eight students of Educational Science participated in asynchronous CSCL discussions in groups of three. An external collaboration script consisting of scriptlet scaffolds was found to impede individual knowledge acquisition. Applying the optimal scripting level principle as a theoretical lens, students in this study may already have had adequate scriptlets at their disposal and thus did not need further scriptlet scaffolds. Hence, processing these scaffolds may have caused unnecessary load.

Scripting at a level that is too low (i.e., too specific) for a learner, as supposedly happened in the study by Mäkitalo et al. (2005), can constitute a problem not only for the acquisition of subject matter knowledge, but also for the internalization of a collaboration script. Such an external collaboration script takes regulation away from the learners and may thereby prevent them from developing higher-level internal script components. Learners who have recently received support from an external collaboration script have been guided by the specific constellation of internal script components induced by the external collaboration script (according to principle 1) and are thus likely to develop corresponding higher-level internal collaboration script components that integrate these components (according to principle 3). Accordingly, with repeated application, the optimal external scripting level shifts to higher levels. Thus, the optimal external scripting level principle implies that learning is more likely to happen when learners are given the opportunity to apply their newly developed higher-level script components for regulating their activities. A straightforward way to provide this opportunity is by fading out external collaboration script components.

Evidence for the influence of fading comes from a study by Wecker and Fischer (2011), in which learners, supported by either an unfaded or a faded external script that included scriptlet scaffolds on different levels of specificity, were required to write counter-arguments in an asynchronous online discussion. Learners in the faded script condition acquired higher-quality internal scripts about argumentation than learners in the unfaded script condition, provided that their learning partners monitored how they followed the strategy of argumentation suggested by the external script. This finding indicates that, provided that continuous application of the script is secured, adjusting the level of an external script through fading can lead to improved script internalization.

According to this line of reasoning, it is a crucial prerequisite for a positive effect of fading on the development of an internal collaboration script that learners continue to act in accordance with the strategy suggested by the external collaboration script. The importance of this pre-condition is emphasized by two further studies: A study by Stegmann, Mu, Gehlen-Baum, and Fischer (2011) showed that there was no positive effect for an external collaboration script that was simply faded over time without additional instructional means to secure the continuous application of the strategy suggested by the external collaboration script. Similarly, a study by Wecker, Kollar, Fischer, and Prechtl (2010) investigated the effects of a faded external collaboration script in contrast to a continuously available external script with respect to the development of an internal script. In this study, the gradual fading-out procedure for an external collaboration script guiding collaborative information search in a learning environment on genetic engineering continued for several weeks. The fading-out process was controlled by the number of information searches the learners conducted and not by the actual quality of the collaborative search and discourse processes. Results showed that learners with the faded external script did not internalize the script on information search better than learners with a continuously available (unfaded) script.

A further implication of the optimal external scripting level principle is that fading that is adapted to the learner's current state in the development of internal script components should be more effective for script internalization than fixed fading regimes. In a more adaptive realization of fading, Tsovaltzi et al. (2010) provided scaffolds of an external collaboration script that were continuously adjusted to the quality of contributions to the discussion. The authors compared processes and outcomes of three dyads supported by a non-adaptive external collaboration script with three dyads supported by an adaptive external collaboration script. Specific components of

the external collaboration script were adaptively presented in response to a low quality of the respective discourse indicators. Qualitative and descriptive quantitative results indicated that learners with the adaptive external collaboration script outperformed learners in conditions without an external collaboration script and continuously available external collaboration script.

Conclusions and Future Research

This article presented an outline of a script theory of guidance in CSCL. According to this theory, internal collaboration scripts develop as an attempt by learners to effectively understand and act in recurring CSCL practices. These CSCL practices are themselves shaped by the internal collaboration scripts of the participating individuals that consist of the components play, scenes, scriptlets, and roles. Sufficiently flexible internal collaboration scripts are modified dynamically if they do not lead to successful understanding or acting in a collaborative practice according to the individual goals of the learner or if the situation changes. New internal collaboration script components develop as (re-)configurations of existing collaboration script components that are successfully employed together to reach the learner's individual goals. With respect to the acquisition of knowledge, CSCL practices that require transactive application of knowledge are regarded as more effective than non-transactive ones.

External collaboration scripts consist of scaffolds that stimulate or inhibit internal script components (play scaffolds, scene scaffolds, role scaffolds, scriptlet scaffolds) to help learners acquire new higher-level internal script components and subject matter knowledge. With respect to learning, external collaboration scripts are more effective if their scaffolds stimulate a self-directed employment of script components as much as possible. In that sense, optimal scaffolds address internal script components on the highest level possible where subordinate components

are already part of a learner's cognitive repertoire rather than redundantly prescribing how and in which sequence specific activities should be performed. Thus, the script theory of guidance for CSCL can inform the design of external collaboration scripts with respect to when they can effectively be used, which scaffolds are likely to induce the application of specific internal script components, and how these scaffolds can be removed to increase the likelihood of a self-directed configuration and application of internal script components.

Empirical studies in CSCL show that well-designed external collaboration scripts enable learners to engage in complex CSCL practices beyond what they would be able to do on their own. As a consequence of participating in CSCL practices that are improved in this way, participants develop more elaborate internal collaboration scripts. Well-developed internal scripts are self-regulation tools for the acquisition of knowledge through CSCL practices. One of the open questions for script research is how subject matter knowledge and collaboration scripts relate. The script theory of guidance assumes that subject matter knowledge is more likely to be acquired through its transactive use in CSCL practices. There are some empirical findings that can be considered as supporting this principle (e.g., Stegmann, Weinberger, & Fischer, 2011). It may however be argued that processes of internal script induction and reconfiguration on the one hand and subject matter knowledge acquisition on the other hand are not always synergetic. There is evidence that the existence of a well-developed internal script prior to the collaborative learning phase is beneficial for subject matter knowledge acquisition (Kollar et al., 2007). A straightforward consequence seems to be that it is more effective to first facilitate the development of the internal collaboration script and then collaboratively learn the subject matter knowledge (O'Donnell & Dansereau, 1992). However, this approach would leave major advantages of CSCL technology unused, namely, the targeted and possibly adaptive support

during collaboration. Additionally, some studies show that process-related scripting support can substantially promote subject matter knowledge and internal collaboration scripts simultaneously (e.g., Wecker, Kollar, et al., 2010). Future research should address the relation of script induction/reconfiguration and subject matter knowledge acquisition more directly, for example, by varying the degree of elaboration of the internal script experimentally and by analyzing how subject matter knowledge is associated with internal scripts.

Another interesting open question for script research is to what extent the script components and levels currently included in the script theory of guidance (play, scene, scriptlet, and role) are a helpful conceptual toolkit to analyze and design all kinds of collaborations scripts. For example, a subset of CSCL practices based on joint problem-solving includes recurring sequences of scenes that can be described as exploration, solution and evaluation (Slof, Erkens, Kirschner, Jaspers & Janssen, 2010). Applying the script theory of guidance one would conceptualize an exploration phase as a scene that, in turn, includes a number of scenes itself. However, it might be worthwhile to explore conceptually and empirically, whether the inclusion of additional levels and components such as an "act" component could further advance the analysis and design of scripts for specific CSCL practices..

A further important topic for discussion is related to supposedly too high levels of external support for CSCL. It is a widespread misconception of CSCL scripts that they are rigid digital stencils of interaction meant for ensuring individual knowledge acquisition — at the expense of naturally occurring collaboration. In contrast, collaboration scripts should be regarded as external aids for a phase when higher-level internal collaboration script components are not available or cannot be spontaneously transferred from the memory of previous experiences to the current situation. External collaboration scripts are primarily a means of preventing *under-*

scripting effects (i.e., little learning due to too open learning environments that leave too many degrees of freedom or place too high a load on the learner; see Kirschner, Sweller, & Clark, 2006). However, research also indicates that students learn from failure (see Kapur & Kinzer, 2009; Schank, 1999) when they realize that their internal scripts are not functional. This is reflected in the internal script reconfiguration principle. An interesting open question concerns how learning environments can be designed to more systematically enable productive failure in collaborative learning without withholding necessary guidance.

Another interesting topic for future collaboration script research is fading (e.g., Wecker & Fischer, 2011). Currently, a lot of research effort is devoted to the conditions under which adaptive and adaptable CSCL scripts are effective (Diziol, Walker, Rummel, & Koedinger, 2010; Tsovaltzi et al., 2010). The adaptive fading of external collaboration scripts might be an interesting topic for research from a developmental point of view as well. While the amount of external script support required for optimal learning of a specific skill may decrease over time, it seems plausible that the collaborative practices in which children engage increase in complexity as children develop into adolescents and adults. Therefore, the overall degree of external scripting might remain on a relatively constant level over an extended timeframe while the specific content of the external script support changes.

Yet, in future research and practical implementations of more adaptive external collaboration scripts, better and more efficient methods for diagnosing internal collaboration scripts are needed. To develop effective diagnostic tools, it seems plausible to refer back to standard methods of schema and script research such as recall measures and reaction times. However, we argued that internal collaboration scripts are multilevel configurations of components that can be dynamically re-configured as a response to changing situations and to

changing individual goals. Diagnostic tools thus have to take this dynamic and adaptive nature into account. Promising recent advances in computer linguistics could be systematically explored to diagnose dynamic internal collaboration scripts during their use in a particular CSCL setting (e.g., Mu, et al., 2012; Rosé et al., 2008). Beyond improved diagnostic tools, machine-readability is another precondition for adaptive external collaboration scripts. Script formalization is a challenging interdisciplinary endeavor toward a psychologically valid and yet machine-readable description of essential script components (Hernandez-Leo et al., 2010; Ronen, Kohen-Vacs, & Raz-Fogel, 2006).

Another important issue is self-regulation and metacognitive awareness of the internal collaboration scripts. It can be argued that an increased number of internal collaboration script components contribute to an increased freedom of a learner: At any given situation, there are potentially more options to understand and to act. However, the script theory of guidance does not explicitly address the learners' awareness of their own internal scripts. More specifically, it does not elaborate on a metacognitive component that would enable *conscious* selection of internal collaboration script components. Yet it seems to be a promising route for future theory-building to relate the script theory of guidance to the emerging research on shared regulation and co-regulation (Järvelä, Hadwin & Järvenoja, this issue). A paradigmatic bridge between research on scripting and research on co-regulation seem to exist already: *Adaptable* external scripts, which require learners to discuss which components of the external collaboration scripts to keep and which ones to switch off (Wang, Kollar, Stegmann & Fischer, 2011).

On a more comprehensive theoretical level, this article proposes an instructional theory that builds on a recent version of schema theory, dynamic memory theory (Schank, 1999), to overcome one major problem of early schema theories, namely the issue of schemas and scripts

as cognitive structures too rigid to explain the highly adaptive behaviour that individuals exhibit in social practices. However, the theory proposed here extends the theory of dynamic memory by more explicitly linking the cognitive side to the collaborative practice considered to be both the origin and a field of application of cognition. The proposed theory draws on socio-cultural ideas, especially the Genetic Law of Development and the ZPD (Vygotsky, 1978). We believe that the script theory of guidance in CSCL has the potential to establish a closer link between cognitive theorizing on collaborative learning in psychology on the one side, and organizational and institutional research on collaboration in other social sciences on the other. The multidisciplinary field of CSCL is a promising context to explore and possibly strengthen this link.

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