Principles of Transactive Computer-Supported Collaboration Scripts

Armin Weinberger

Armin Weinberger
Professor, Saarland University, Germany.
a.weinberger@mx.uni-saarland.de

English abstract

Parts of the classroom of the future may be built online allowing for computer-supported collaborative learning (CSCL). A central challenge in CSCL is a lack of transactivity, i.e., learners have problems building on the reasoning of their peers. A means of fostering CSCL are scripts that specify, sequence, and distribute roles and activities among a group of (online) learners. This article identifies five instructional design principles that explain script effects and inform script design: 1) regulation of learning activities; 2) complementary procedural knowledge; 3) process-oriented instruction; 4) substitution of coordination efforts; and 5) awareness induction.

Keywords: Computer-supported collaboration scripts, CSCL, transactivity
Introduction

Traditional classrooms have been criticized for too little student participation and for fostering abstract and static knowledge rather than enabling learners to engage in argumentative practices within specific domains. Educational technologies allow students to create, share, and receive information inside and outside the classroom, and support active, self-regulated, and collaborative forms of learning (Scardamalia & Bereiter, 2006). Blending classroom interactions with computer-supported collaborative learning (CSCL) has been one of the recent approaches for developing educational practice – not only because of the technological advancements in online learning, but also because of a better understanding of active knowledge construction in communities of learners. In contrast to handing down information in the traditional classroom and in response to an ever-growing culture of sharing multi-media messages online, CSCL environments can be designed in ways that allow for new forms of (collaborative) learning and opportunities for active participation in knowledge construction. In CSCL learners are typically expected to discuss and inquire complex phenomena with little or no direct interference from (university or school) teachers.

Although CSCL may provide ‘any place or time’ opportunities for learners to construct and revisit sound arguments that are linked to additional online resources, many learners have difficulties exploiting these opportunities when simply assigned to groups and left to their own devices. Learners without additional guidance to critically review others’ arguments and construct sound arguments themselves rarely engage in such interactions, instead orienting themselves toward the minimal requirements of a learning task and quickly building false consensus as a result (Weinberger, 2008). Particularly problematic for online learners is the coordination of interactions, referring to and building on learning partners’ contributions, and engaging in and maintaining coherent, joint reasoning (Hesse, Garsoffky, & Hron, 1997). This crucial issue in CSCL has been conceptualized as the transactivity of learners’ interactions, i.e., the extent to which learners build on others’ reasoning and potentially arrive at a shared understanding (Weinberger & Fischer, 2006). In sum, collaborative learning in complex, technology-enhanced environments is often motivationally and cognitively demanding, and it seems inadequate to simply provide students with technology and ask them to inquire into problems or share knowledge outside the classroom. Therefore, CSCL seems to benefit widely from additional facilitation of specific learning activities during the learning process.

In recent CSCL research, the collaboration script approach has been widely discussed (Fischer, Mandl, Haake & Kollar, 2007). The main idea of computerized collaboration scripts is to promote productive interactions by designing the environment such that suggestions of different degrees of coercion are made to the collaborating students, engaging them in specific activities that otherwise might not occur (Kollar, Fischer, & Hesse, 2006). Collaboration scripts provide learners with a specific socio-cognitive structure and map a specific interaction pattern with distributed roles onto a group of (online) learners. This can be achieved by software design, e.g., blocking the ability to post a message until all group members have reacted, prompting certain sequences of dialogue moves (e.g., claim – counterclaim – rebuttal), or assigning and rotating collaborating learners’ specific responsibilities and roles, such as analyser and critic. Scripts may thus provide an educational design to online learning without direct teacher intervention, providing a scaffold for learners outside the classroom and bridging online to classroom learning activities. In this conceptual design article, different types of scripts will be introduced; an overview of empirical research on CSCL scripts will be given; some caveats of the scripting approach will be outlined; and finally, some script principles will be discussed informing scripts’ instructional design.
Macro and micro scripts

Different families of scripts have been designed and explored that can be coarsely categorized into macro and micro scripts (Dillenbourg & Hong, 2008; Fischer et al., 2007).

Macro scripts arrange learning activities by grouping and regrouping learners, distributing (different) resources and access rights, as well as sequencing different learning arrangements, e.g., intertwining classroom, individual and collaborative learning phases. Macro scripts organize groups and sequences of learning arrangements to bridge between formal and informal education, to reduce process losses of coordination in groups of learners, and to raise specific expectations and awareness of the specific learning sequences and arrangements.

Micro scripts support collaborative learning by specifying and distributing roles and activities within groups of learners. Micro scripts are typically realized through structuring the communication interface, e.g., through prompts such as ‘The following aspects are not clear to me yet’ (Weinberger, Ertl, Fischer, & Mandl, 2005; Weinberger, Stegmann, & Fischer, 2010). Micro scripts inform learners what to do and how to engage in specific learning activities. Thereby, micro scripts represent procedural knowledge and heuristics with which learners typically need to engage in specific learning activities, such as constructing sound arguments.

Script effects

Several studies have shown that software-embedded CSCL scripts may improve online group functioning, and subsequent individual achievement (e.g., Rummel, Spada, & Hauser, 2009; Stegmann, Weinberger, & Fischer, 2007; Weinberger et al., 2005). Scripts can be designed to facilitate specific discourse qualities, producing the wanted main results, but also unwanted side effects (Weinberger, Reiserer, Ertl, Fischer, & Mandl, 2005). For instance, a script prompting learners toward specific epistemic steps necessary to solve a problem may increase task performance. However, this script may also reduce the transactivity of learners’ discussions and ultimately, individual learning gains (Weinberger, Ertl, et al., 2005). In contrast, a peer-review script may assign and rotate learners’ roles as case analyst and constructive critic, facilitating these roles with prompts such as ‘My proposal for an adjustment of the analysis is…’. This peer-review script aims to facilitate conflict-oriented consensus-building and has been shown effectively to increase the transactivity of learners’ discussions. Simultaneously, this script made the collaborative task more demanding and reduced performance during the CSCL processes, but substantially improved individual learning outcomes (Weinberger, 2008). In sum, scripted CSCL can outperform unscripted computer-supported individual and collaborative learning with respect to individual learning outcomes (Weinberger et al., 2010).

Over-scripting and script adaptability

Collaboration scripts have also been criticized. One critical issue is the degree of coercion to which scripts suggest or dictate interaction, and it has been argued that overly coercive micro scripts can dampen student motivation (Rummel, Spada, & Hauser, 2009). More fundamentally and not based on empirical data, it has been argued that scripts potentially impair self-regulated, playful and exploratory thinking and hence betray core CSCL principles (Dillenbourg, 2002). Finally, scripts may interfere with personal, possibly well-functioning internally represented collaboration scripts, i.e. learners’ procedural knowledge about how to collaborate and solve a task (Kollar, Fischer, &
This critique is based on the premise that scripts externally provided within a learning environment interact with learners’ internal scripts. Therefore, only learners with unspecific or dysfunctional internal scripts are to be provided with highly detailed external scripts, whereas learners with functional internal scripts are to be provided with less detailed or no scripts at all (Cohen, 1994). Complicating this situation somewhat is the fact that students are typically supposed to develop specific internal scripts while they are engaging in collaborative learning activities. Therefore, external scripts need to be adapted to learners’ advancing knowledge. Adaptive scripting requires continuous assessment of learners’ developing internal scripts and strategies for fading out scripts. Some progress has been made in automatically assessing learners’ online discussions as a basis for adapting scripts (Rosé et al., 2008). Some progress has also been made towards systematically breaking down scripts into components that can be faded out successively (Kobbe et al., 2007). Still little is known, however, on the underlying script principles and how scripts can be designed to facilitate internalization of the procedural knowledge that is represented in external scripts (Wecker & Fischer, 2008).

Script principles

Scripts may build on various underlying principles that could explain why scripts are an effective instructional approach for CSCL. Scripts can take over regulation of the learning process. Scripts can be regarded as an external representation of knowledge that complements a system of knowledge that is distributed among learning partners and the environment. A direct-instruction function of scripts is to make learners engage in activities that are related to knowledge construction, e.g., elaboration of arguments. Scripts can also reduce process losses in complex collaborative learning arrangements by taking over tasks that are not inherently related to learning, e.g., coordination of turn-taking. Moreover, scripts can make learners aware of the different responsibilities within the group and thereby facilitate beneficial motivational states and self-regulation. Overall, scripts can:

1. regulate learning activities
2. provide complementary procedural knowledge
3. provide process-oriented instruction
4. alleviate coordination
5. foster awareness

In the following, these underlying script principles will be elaborated with respect to their theoretical background and exemplified with specific scripts whose effects have been empirically tested.

Regulation of learning activities

In complex learning environments, learners are supposed to work on tasks that they cannot yet accomplish without additional help, i.e. tasks within the learners’ respective zones of proximal development (ZPD) (Vygotsky, 1978). Tasks outside the ZPD are those from which learners can either not learn anything new or are too difficult to be mastered by learners of a certain developmental stage even with some additional help. Initially, the learning process should be structured to a larger degree, e.g. by external scripts, enabling learners to develop internal scripts and successively master more of the learning task in the ongoing learning process. To achieve this, scripts may guide learners’
attention toward specific aspects of a task, model the problem-solving process, or provide learners with additional learning resources. For instance, an epistemic script based on the idea of structuring a task (Weinberger et al., 2005) provided learners with step-by-step guide to identify relevant problem information, apply theoretical concepts to the problem information, and make inferences on future developments and possible interventions, modelling an expert strategy to solving specific problem cases.

In an ideal case, increasing self-regulation by internal scripts develops in a perfectly negative relation to a fading support by an external script (see Figure 1). In practice, learning is not a perfectly linear process. Instead, learners reach plateaus or even regress sometimes, resulting in a step-like learning curve. Educational designers and practitioners are therefore challenged to continuously adapt external scripts to advancing internal scripts. A mismatch of external and internal scripts may principally either lead to momentary lack of support (under-scripting) or interfere with the developing scripts of learners (over-scripting; Dillenbourg, 2002). Especially, overly coercive micro scripts may not only be dysfunctional owing to conflicting scripts regulating the group, but may also dampen student motivation by shifting the perceived locus of control towards the external script (Rummel et al., 2009). So far, however, empirical studies investigating a potential conflict between internal and external scripts (Kollar et al., 2007) and motivational drawbacks (Rummel et al., 2009) show that also learners with highly structured internal scripts benefit from high-structure external scripts, and that scripts have not reduced learning motivation in comparison to other forms of instruction or self-regulated learning. Therefore, it seems feasible to regulate the learning process to different degrees at different times by external scripts, with the goal of enabling learners to accomplish the task and in alignment with learners’ goals.

Complementary procedural knowledge

Some scripts represent expert heuristics or procedural knowledge that constitutes an additional learning goal. Learners are then supposed to internalize the script procedure (see Figure 2). In this view, learners build a system of distributed knowledge together with the script (Perkins, 1993), and
scripts represent procedural knowledge that learners can tap into to regulate their collaborative learning activities. A workplace example for such a distributed system would be an airplane crew using a checklist to control the plane’s functions. Scripts may then take into account how knowledge is distributed within a group of learners. For instance, the ArgueGraph script (Jermann & Dillenbourg, 2003) assesses learners’ prior knowledge and opinions about a controversial topic and groups the learners with the goal of organizing maximally heterogeneous dyads to foster elaboration and modification of their opinions through critical debate. The dyads arrive at a joint conclusion on the topic, which is then displayed and reflected in a moderated classroom discussion.

![Figure 2. Idealized sharing and internalization of task-relevant knowledge distributed between script and co-learners before (left) and after (right) scripted CSCL](image)

According to Perkins’ (1993) conceptualization, to internalize procedural knowledge represented in scripts, this knowledge needs to be represented in a way that can easily be picked up, internally represented, retrieved, and re-constructed by the learners. Moreover, learners need to have some understanding of the mostly tacit procedural knowledge being a worthwhile learning goal in the first place.

**Process-oriented instruction**

Having identified specific discourse practices and interaction patterns related to learning, scripts can increase the chance for learners to engage in those activities. Instruction by scripts expects a specific behaviour of learners. However, instructing learners requires some authority of the script representation to foster script adherence, e.g. a teacher introducing the script. As many computer-supported collaboration scripts are represented within the environment through text prompts only – as opposed to being instructed by a teacher – CSCL scripts typically allow for learners to disregard the script instruction. Especially non-adaptive scripts stand a good chance of being regarded as redundant by some of the students at some time in the learning process.

To increase the frequency of specific behaviour, the script may therefore constrain or afford specific activities as well as make concrete suggestions, or prompts, on how to act. In this way, scripts can specify a set of activities learners can engage in. Moreover, scripts can align the specified activities in a specific sequence and assign activities to specific learners within a group (see Figure 3). Typically, scripts instigate role rotation to facilitate equal participation in the different learning activities. For instance, Hron et al. (1997) sequenced the interaction of learners by alternately prompting learners to propose correction of the learning partner, explain the correction, and obtain agreement from
the learning partner. Only when both partners reached agreement was the interface accessible to realize the correction.

CSCL scripts aiming at different sets of roles and activities have been shown to facilitate those activities in targeted manners (Weinberger, Reiserer, et al., 2005). These include a participation script to increase learners’ participation, argumentative scripts facilitate specific argumentative discourse qualities, and scripts suggesting specific steps towards solving a task that increase the chance that learners actually manage the task-solution moves. Orientating learners towards specific social and cognitive activities, however, happens often at the expense of other activities. It is thus difficult to attain a balanced script design, in which learners are guided to solve the task on one hand, but also discuss and jointly elaborate the learning material on the other. Particularly problematic in this context is the notion that scaffolding should sometimes make a learning task more difficult (Reiser, 2004). This may result in decreased performance in terms of solving the learning task, but facilitate understanding of multiple perspectives of the concepts that are to be learned. It may be counterintuitive for script designers to aim at complicating the process of solving the learning task to some extent, e.g., introducing such additional tasks as warranting claims or finding counter-evidence, which have been shown to improve learning in empirical studies (Stegmann et al., 2007; Weinberger et al., 2010).

Substitution of coordination efforts

Collaborative learners in online environments typically need to put more effort into coordinating themselves than in face-to-face environments, and this seems to impede learning (Gräsel, Fischer, Bruhn, & Mandl, 2001; Hesse et al., 1997; Kiesler & Sproull, 1992; Strijbos, Martens, Jochems & Broers, 2004). Consequently, a focus of CSCL research has been investigation of how learners coordinate their shared understanding (Beers, Boshuizen, Kirschner, & Gijselaers, 2007). CSCL places additional coordination demands on learners, creating ‘process losses’ depending on communication modalities of the specific online learning environment. Process losses may result in advantages of individual computer-supported learning compared to CSCL (Weinberger et al., 2010), in that the coordination of group activities may repeatedly interrupt the socio-cognitive elaboration of learning material, a key aspect of CSCL. Coordination of online learning activities may be indispensable, but only indirectly related to learning itself (see Figure 4).
Scripts have been shown to address coordination demands and reduce process losses (Weinberger et al., 2010). Scripts may coordinate grouping of learners, distribute tasks among a group of learners, and time the collaborative learning process. For instance, Baker and Lund (1997) pre-structured interactions of learners in a detailed manner by providing buttons for specific speech acts in a text-based interface of a CSCL environment. The buttons are labelled with speech acts, such as “I propose to...” “Ok,” “Wait!” etc., that could be pasted into the interface and eventually completed by the user. Learners were expected to use those buttons to reduce demands of typing. There is empirical work yet to be done investigating under what circumstances coordination-oriented scripts do not only ease and speed up processes of online learning, but also result in substantial learning gains (Weinberger, Reiserer et al., 2005). So far, this script research has been carried out in a number of domains, such as education, psychology, medicine, and natural sciences in university and school education. Although the scripting approach was first applied to facilitate collaborative reading (O’Donnell & Dansereau, 1992), most script research is now building on relatively complex tasks and debatable topics.

**Awareness induction**

A topic that has been under-investigated in script research is the extent to which scripts may enhance learners’ awareness of group processes and status (Hesse, 2007). Awareness is particularly crucial in computer-mediated environments, since context information and personal background information about collaboration partners are often lacking, incomplete or even faulty. Common awareness features that have been investigated are, among others, awareness of the presence and activities of others (Prinz, 2001), the knowledge states of others (Engelmann et al., 2009), workspace and the group structure (Gutwin & Greenberg, 2002; Gutwin, Greenberg, & Roseman, 1996). From an awareness perspective, scripts could be regarded as changing the expectations that students develop with regard to the goals and the social parameters of the argumentative interaction phase, including how roles and activities will be distributed and rotated within the group of learners (see Figure 5).
Figure 5. Awareness of how roles and activities are distributed and will be rotated within a group through a script.

Research on accountability effects in non-computer-supported collaborative learning has shown that even the mere anticipation of an audience improves students’ tendency to engage in critical thinking (Renkl, 1997). Scripts can thus be designed to reassure learners of the mutual commitment of their partners, which has been found to be a major problem of learning in groups (Kerr, 1983). In this view, learners need to be informed beforehand of the general script structure to be regarded as a kind of contract and preview of the collaboration process (Döbeli Honegger & Notari, 2009). For instance, learners may get to know that each learning partner will exert a certain role, and that after some time those roles will rotate (Palincsar & Brown, 1984). This may alleviate some of the well-known motivational problems associated with small groups (Kerr, 1983).

Discussion

Scripts may facilitate learning by building on different instructional principles, described above as:

1. regulating learning activities
2. complementing procedural knowledge
3. providing process-oriented instruction
4. substituting coordination efforts
5. inducing awareness

The different script principles, in turn, inform script design. For instance, scripts that are supposed to alter learners’ expectations need to be made clear to learners before the learning process to raise awareness of how the script will structure the collaborative learning process and distribute responsibilities. Similarly, some level of awareness of the procedural knowledge represented within scripts and the experience of its usefulness for pursuing one’s goals is beneficial for internalizing this procedural knowledge. In contrast, the instruction and substitution of activities may not require a detailed mental representation of a script.

In this section, I return to the question of how the different script principles can facilitate transactivity. Transactivity means that learners relate to the knowledge contributions of their peers
in collaborative learning scenarios (Teasley, 1997; Weinberger & Fischer, 2006). For transactive talk, learners need motivationally and cognitively to engage in processes of speech reception and production, such as:

- being aware of contributions by their learning partners
- directing attention toward these contributions
- understanding to some degree what their partners are saying
- constructing a model of the knowledge of their learning partners
- searching for or activating their knowledge; and articulating a response that relates to the knowledge contributions of their partners.

Scripts thus provide a scaffold for singular transactive discourse activities on micro and macro levels, building on different principles to different degrees.

The core question of how the different script principles can facilitate transactivity of computer-supported collaborative learners concerns the extent to which learners need to be self-regulated versus externally regulated by a script. Transactive CSCL requires learners to actively and autonomously manage and organize their collaborative learning activities. At the same time, transactive talk is demanding in terms of the argumentative competencies the learners need. The script principles presented above differ with respect to how much control is left to the learner and how much is regulated by a script, as well as to what extent scripts represent knowledge that learners should internalize.

*External regulation through scripts* may foster transactive discourse as long as learners are incapable of engaging in transactive talk themselves. Few unscripted learners effectively apply self-regulation strategies for transactive collaborative learning, such as sufficiently analysing online learning partners’ contributions and their relation to one’s own standpoints. As discussed, findings from empirical studies confirm that scripts can facilitate specific process characteristics of CSCL, and that some scripts are greatly beneficial to individual knowledge construction. There is further need, however, to investigate scripts against the background of the five instructional script design principles discussed above, as there is currently little knowledge of how the substantial effects from scripts are realized. Moreover, there are challenges in identifying when students become capable of accomplishing a task on their own, in the successive transition from external to internal regulation (Wecker & Fischer, 2006).

*Scripts may represent procedural knowledge*, including the transactive strategies that learners are supposed to acquire. An immediate experience of the usefulness of a specific script may foster motivation and orientation towards internalizing the strategies represented by the script. However, the experience of immediately appreciating the knowledge a script represents is often minimal against the background of the extra effort transactive scripts impose on learners.

*Scripts may instruct* and also coerce learners to various extents to engage them in a specific strategy. Script instruction may increase frequencies of observable transactive discourse activities (Weinberger, 2008). Transactivity implies, however, that learners construct internal representations of their partners’ knowledge. Studies in University education show that scripts can facilitate the extent to which learners are not only engaging in transactive talk, but also cognitively building on...
their partners’ contributions and arriving at shared knowledge (Stegmann et al., 2007; Weinberger, Stegmann, & Fischer, 2007). Younger school students, however, may not necessarily aim to follow script instructions with an understanding of the script rationale (Weinberger & Gijlers, 2010).

Additional coordination efforts of CSCL may make it particularly challenging for learners to engage in transactive talk rather than building consensus quickly (Weinberger & Fischer, 2006). For learners to transactively respond to their peers, they need to have access to peer contributions in a timely manner. Scripts may coordinate discourse moves and, for instance, prompt contributions from peers. Reducing process losses by substituting coordination, however, may not necessarily lead to learners acquiring internal representations of transactive strategies.

Typically introduced before the collaboration process, scripts induce some level of awareness about the roles, responsibilities, and interaction patterns that are foreseen for the group and its members. Hence, scripts can be regarded as a type of advance learning contract. To foster transactivity, scripts can raise expectations about individual responsibilities in solving the task and about how co-learners will build on their respective contributions. With making scripts adaptive (Rosé et al., 2008), learners can be continuously made aware of their status and distribution of participation, knowledge, and the transactivity of their interactions. Creating awareness may not suffice to regulate learning behaviour, but in addition to raising awareness, scripts suggest strategies for learners to enhance collaboration tailored to their needs.

Combining the outlined principles, scripts may strike a balance between instructing and regulating on the one hand, and providing knowledge and awareness on the other. Ultimately, scripts may not only need to alter expectations, orchestrate different learning arrangements, and adaptively suggest specific discourse activities, but also allow learners to position themselves with regard to each other and the debated topic. In this respect, it is necessary to discuss what should be scripted to avoid under- or over-scripting. In this way, learners may be encouraged to increasingly engage in transactive online discussions outside the traditional classroom.

References


