Chapter 12

COMPUTER-SUPPORTED COLLABORATION SCRIPTS

Theory and Practice of Scripting CSCL - Perspectives of Educational Psychology and Computer Science

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Abstract: Students can be motivated but still not be able to engage in specific cognitive activities in computer-supported collaborative learning (CSCL) environments. Students are often at loss of what to do or may dispose of procedural knowledge on how to collaborate that is inappropriate for acquiring knowledge individually through CSCL. Facilitating specific CSCL processes by providing learners with computer-supported collaboration scripts is an approach well investigated and feasible for CSCL. Implemented in CSCL environments, computer-supported collaboration scripts specify, sequence, and distribute roles and activities. Scripts are supposed to scaffold activities that students could not yet engage in based on their procedural knowledge alone. Continuously adapting scripts to learners' needs and procedural knowledge is one of the main challenges of this approach to realise effective CSCL. Efforts to specify and formalise script components and mechanisms have led to an integrative framework for computer scientists, educational scientists and psychologists towards what constitutes computer-supported collaboration scripts and contributed to a growing library of prototypical CSCL scripts.

Key words: collaboration script, computer-supported collaborative learning (CSCL), external script, internal script, scripting

Collaborative learning is a central component of many current theoretical approaches to learning and instruction and is assumed to foster specific learning processes and outcomes. Having the ownership of their learning processes, collaborative learners are supposed to elaborate and share knowledge with peers and thus acquire and become able to apply domain-specific knowledge as well as attain soft outcomes, such as self-esteem, motivation, and social skills (Johnson & Johnson, 2002; Lave & Wenger, 1990; O'Donnell & King, 1999; Slavin, 1995; Vygotsky, 1978). However, implementing effective collaborative learning into schools and universities today is a challenging task. Imagine a university teacher giving an introductory lecture to about 100 participants on some basic approaches of educational psychology, such as attribution theories. Beyond the lecture itself, in which the basic theories should be introduced, the lecturer wants the students practicing to apply the psychological theories to single problem cases collaboratively including additional literature in their work. Computers can support collaborative learning through a number of communication and representation tools, such as asynchronous discussion boards or wikis, creating a virtual space for students to work on learning tasks together (Computer-Supported Collaborative Learning - CSCL; Stahl, Koschmann, & Suthers, 2006). Simply assigning a collaborative task and providing learners with communication tools, however, may not suffice to establish effective (computer-supported) collaborative learning. Instead, both teachers and learners may require elaborate strategies to realise effective collaborative learning.

Computer-supported collaboration scripts or CSCL scripts are an approach to set up and facilitate effective collaborative learning. On a macro-level, CSCL scripts can structure and link lectures, individual and collaborative learning phases in face-to-face or in computer-mediated environments. The university lecturer might design a script, for instance, which times and distributes resources between the lecture and an online environment. For instance, additional literature could be pointed out in the lecture that is downloadable in an online platform accompanying the lecture. After handing out specific reading assignments to individual learners, groups of four could be formed. In these groups, learners could be assigned the task to collaboratively analyse problem cases on the basis of the theoretical texts they have read.

On a micro-level, CSCL scripts scaffold specific collaborative learning processes and provide learners with more or less detailed instructions concerning the types and sequence of different activities and roles they are supposed to perform during collaboration (Kollar, Fischer, & Hesse, 2006). Different from early approaches to scripting, CSCL scripts may be designed in a flexible way to guide learners to communicate and share representations of their knowledge. Besides supporting the implementation of scripts in a specific learning environment, computers can also support the design and adaptation of scripts to different learning environments. In the university lecture example specific interaction patterns could be facilitated by assigning different roles to the students, such as case analyst and constructive critics. These roles in turn can be supported by sentence starters provided in asynchronous discussion boards within the CSCL platform, such as "The most important theoretical concepts that can be applied here are …" or "What I did not understand was…" (see Weinberger, Ertl, Fischer, & Mandl, 2005).

For the remainder of this chapter, this scenario will be used as a joint reference when synthesising recent theoretical, empirical and design-related developments in educational psychology and computer science leading to the specification and formalisation of CSCL scripts. In the following sections, we will address how CSCL scripts can be designed to facilitate learners' transition from other- to self-regulation and outline a vision for future research and practice.

1. A SCRIPT THEORY OF COLLABORATIVE LEARNING

An essential aspect of most forms of collaborative learning is that peers are verbally negotiating with each other how to solve specific learning tasks with the goal to individually acquire knowledge. Thereby, learners' interaction processes are assumed to be related to cognitive processes of learning in "spirals of reciprocity" (Salomon & Perkins, 1998). In constructing explanations and arguments, learners outline and thereby restructure their individual knowledge in a linear form. Reciprocally, learners get to receive arguments from their peers, which may comprise additional resources in solving a task and prompt learners to reply and construct new (counter-) arguments. Learners who are able to fairly balance arguments will thus individually acquire knowledge, which in turn enables them to execute cognitive activities on a higher level (Schwarz, Neuman, & Ilya, 2003).

1.1 Internal and External Scripts

Learners often have difficulties to engage in specific collaborative learning activities and often come to inadequate conclusions on learning tasks. Apparently, learners often construct and fail to recognise flawed arguments. Possibly, learners lack procedural knowledge of how to construct arguments and learn together. This procedural knowledge has been conceptualised as participant-generated scripts (O'Donnell & Dansereau, 1992) or *internal scripts* (Kollar, Fischer, & Slotta, in press). From a cognitive psychology perspective, scripts are understood as a particular type of cognitive schemas: they are cognitive constructs that help individuals understand dynamic events and act in meaningful ways in such dynamic events (Kolodner, 2007; Schank & Abelson, 1977). As these internal scripts often appear to be fragmentary and even dysfunctional, collaborative learning has been facilitated with experimenter-generated (O'Donnell & Dansereau, 1992) or *external scripts* (Kollar et al., in press). This instructional approach of external scripts aims to scaffold collaborative learners and facilitate individual knowledge acquisition by specifying, sequencing, and distributing roles and activities. Different from theatre scripts, external collaboration scripts are to guide and not to determine learners' collaborative activities. In this way, external collaboration scripts complement and potentially alter learners' internal scripts. This is especially desirable when scripts represent important strategies within a domain that ultimately should be individually acquired by the learners. Goals of science education may include, for instance, learning how to construct and analyse sound arguments in a domain, how to review literature and critically reflect hypotheses, or how to inquire hypotheses and interpret data. Research on scripts that were aimed to facilitate the construction of single arguments and argumentation sequences has shown to facilitate not only the specified activities during the collaborative phase, but also facilitated the individual acquisition of argumentative knowledge (see Stegmann, Weinberger, & Fischer, in press). But not all scripts are to be internalised. Some scripts or script components may rather regulate arduous functions that are not directly connected to cognitive activities of learning, such as forming specific small groups of learners or regulating turn taking within these small groups (e.g., Pfister, 2005).

An important design decision that needs to be made in the university lecture example is, whether the script itself should induce a strategy that is to be internalised or not. The university teacher may decide that the students of the course should learn to construct sound arguments based on psychological theories. To this end, learners' messages could be denominated as arguments or counterarguments and contain prompts suggesting learners to warrant and qualify their claims.

1.2 Scripts and Observable Interaction Patterns

The basic rationale of the script perspective on collaborative learning implies that students individually acquire knowledge by engaging in specific activities related to learning. In consequence, script design depends essentially on the designer's theoretical model of what specific collaborative learning activities and interaction patterns are related to individual knowledge acquisition. In the perspective of what has been termed *argumentative knowledge construction*, collaborative learners particularly acquire knowledge individually when they construct sound, elaborate, and well-interlinked arguments (Weinberger & Fischer, 2006).

Scripts are meant to facilitate individual knowledge construction mainly through supporting these specific activities, but scripts are merely plans, which are not necessarily realised in their entirety by learners. Especially when several plans exist, the actual observable activities and interaction patterns of learners may be dissimilar to any one script. Both, internal and external scripts, as well as situational components co-determine the actually observable interaction patterns. Although it has been shown that students basically adhere to external script structures, some variance can be found with respect to the degree to which external scripts regulate collaborative learning activities (Weinberger, Stegmann, Fischer, & Mandl, 2007). Especially over longer periods of time, external scripts may become redundant or even dysfunctional when they are not dynamically adapted to learners' needs in the course of collaborative learning. This dynamic adaptation could be realised by teachers who continuously monitored the collaborative learning activities, by the learners themselves who could be left to choose what kind of script support they could select or drop, or by software that could propose scripts to teachers or learners based on automatic analyses of learners' interaction patterns (Dönmez, Rosé, Stegmann, Weinberger, & Fischer, 2005).

There is yet little knowledge, how internal scripts may guide collaborative learners and how learners converge or diverge with respect to how they handle learning tasks together. Typically, students may not explicate their internal scripts. One may assume that learners quickly converge on a common style (e.g., through primacy effects) and participate according to how motivation and competencies are distributed within the small group of learners (Weinberger, Stegmann, & Fischer, 2007a). As little is known on the interaction of internal scripts of different learning partners, there is also little knowledge on how internal and external scripts interact in qualitatively different ways. What is considered established knowledge is, however, that the degree of regulation of external scripts should be adjusted to the degree learners' internal scripts are elaborated to self-regulate their collaborative learning processes (Cohen, 1994).

With respect to the university lecture example, this leaves us with the question how to adapt external scripts to learners' internal scripts? After the university lecturer analysed what kinds of internal scripts the students would hold and how elaborated these internal scripts were, the lecturer could select external scripts that regulate activities that the respective learners would normally not engage in, such as constructing warranted claims. Based on continuous analyses of learners' arguments - possibly supported through automatic discourse analysis software (Dönmez et al., 2005) - the lecturer could decide to gradually fade out the script.

1.3 Transition from other- to self-regulation

Early scripting approaches that had been formulated before computers became ubiquitous learning tools aimed to facilitate collaborative learning processes by instructing learners to engage in a specific sequence of activities (O'Donnell & Dansereau, 1992). Some of these approaches additionally provided learners with scaffolds, such as sentence starters or prompts that learners are expected to respond to and complete when learning together (King, 1999). Different from computer-supported scripts, these early scripts were instructed prior to collaborative learning phases, mostly regulated by teachers and represented in paper form or through verbal instructions only. These early approaches often emphasised that the actual goal of scripting collaboration was to help students become self-regulated learners (e.g., King, 2007). At least in early stages the facilitation of self-regulated learning therefore entails a certain degree of other-regulation (see figure 1; Kollar & Fischer, 2007), which in later stages may be gradually reduced or "faded out" (Pea, 2004). From a script perspective, the transition from other- to self-regulation can be conceptualised as a gradual internalisation of scripts - not including some external scripts that are not meant to be internalised (see above). The goal of this internalisation is that learners become more and more self-guided individuals with the ability to solve problems by relying mostly on their internal resources. Also once internalised, scripts are more effective, because they are more accessible and a smaller load to working memory capacity than external scripts.

In a study conducted in an inquiry learning context, Kollar and colleagues (in press; see also Kollar, 2006) have found that highly structured external computer-supported scripts are indeed able to overlay the internal scripts that learners bring to the collaborative learning situation. However, once the external script was faded out and not available to the learners anymore, the learners did not engage in the activities that were suggested by the external scripts before, but mostly followed their original internal scripts. Thus, there was no evidence for a strong internalisation of external script components. However, the duration of the learning session was rather short. Maybe over longer periods of time, internalisation of external scripts is more likely to be observed. This however is subject to further examination. Possibly, transition from other- to self-regulation can be realised with a continuous fading out of external script components rather than an on-off-switch of scripts. CSCL scripts may be more flexibly designed and capable of being faded out in comparison to teacher-instructed scripts (Kobbe, Weinberger, Dillenbourg, Harrer, & Fischer, in press). Additionally, regulation of activities may be temporarily shifted from external scripts to co-learners, who could continue to control the engagement in the formerly scripted activities. An empirical study on fading out computer-supported collaboration scripts in a university context produced promising results that distributing meta-cognitive functions to co-learners as the script fades out is a feasible way to facilitate the internalisation of scripts (Wecker & Fischer, 2007).

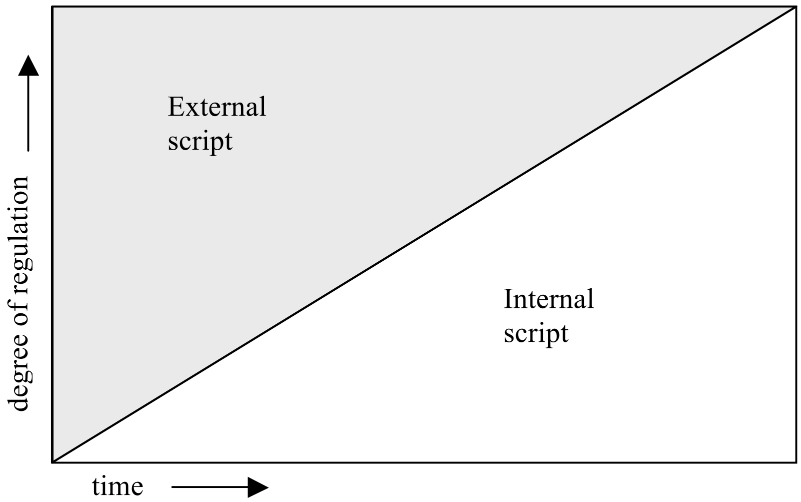

Figure 1: Transition from other- to self-regulation from a script perspective

The university lecturer of our example thus needs to decide on how to support the transition from other- to self-regulation and successively fade out the external script components. As there are indications that fading out in terms of switching scripts on and off does not necessarily lead to learners having internalised the scripts and continuing engaging into activities suggested by the script (Kollar et al., in press), the lecturer might want to motivate students to continue the scripted activities after the script components are being faded out by having the learners mutually control the continuous engagement in the specified activities and possibly also reward engagement in the specific activities.

1.4 How do Computer-Supported Collaboration Scripts work?

Computer-supported collaboration scripts seem to be an effective approach to facilitate specific interaction patterns of computer-supported collaborative learners (see Fischer, Kollar, Mandl, & Haake, 2007). External scripts are, however, ill-defined in terms of how scripts unfold their effect on collaborative learning. Reducing process losses and inducing specific cognitive activities related to individual knowledge acquisition are two major functions of scripts. Introducing computers to classrooms drew attention to the fact that learning and instruction is not only distributed between teachers and students. Cognitive functions may be also distributed among the environment and the tools being used in the learning process. For a first approximation, Kollar and colleagues (2006) have proposed to view CSCL as an instantiation of a "person-plus-surround" system (Perkins, 1993). The basic assumption of such a systemic view on collaborating groups is that cognition does not (only) happen in the individual minds of the learners (the "person-solos"), but that the group as a whole including the artefacts it is using participates in cognition ("person-plus-surround"). When analysing a person-plus-surround system, a crucial question is what component(s) execute metacognitive control such as goal setting or performance monitoring (Perkins, 1993, calls this the "executive function" within the person-plus-surround-system). The question whether students need a script that helps them to perform a particular activity (and thereby takes over the executive function for the system) thus depends heavily on the extent to which the collaborators (or at least one of them) are capable of effectively regulating the group processes themselves.

With respect to inducing activities related to individual knowledge acquisition, scripts represent procedural knowledge learners do not have. However, internal and external scripts do not simply add up so that learners are enabled to engage in specific activities, accomplish the learning task, and individually acquire knowledge. Internal and external scripts may interact in qualitatively different ways that are yet to be investigated (see above). From a scaffolding perspective, external scripts induce activities that learners could not engage in without additional support. The scaffolds provided to the learners do not make activities necessary to complete the task redundant, but lead learners to engage in the activities relevant for individual knowledge acquisition. From this perspective, it is important to limit scripts to take over specific functions, but possibly not replace metacognitive activity relevant for individual knowledge acquisition. If scripts relieve learners of vital collaborative learning activities they might interfere with the social dynamics of the group and even prevent learning in collaborative situations, which has been termed over-scripting (Dillenbourg, 2002). Similarly, scripts might provide too little help for some students or groups, which could be called under-scripting. Therefore, there is a need for identifying an adequate balance between internal and external scripts. One of the major issues in scripting thus is how scripts can facilitate self-regulated learning and include the actual human agents of learning and teaching processes in different collaborative learning activities in authentic classroom contexts.

Scripts may also induce specific activities by altering learners' expectations of what is going to happen in the collaborative phase. Learners expecting to engage in specific activities, such as giving explanations, have been found to acquire more knowledge individually than learners who do not (Renkl, 1997). Making the collaborative scenario more transparent through scripts may also alter the motivational configuration of the small group of learners. Making transparent to the learners that all group members are required to participate homogeneously, for instance, may reduce social loafing and sucker effects (Kerr, 1983; Latané, Williams, & Harkins, 1979). Scripts may also clarify how specific activities may eventually lead to specific wanted results and thus increase learners' motivation (Weinberger & Fischer, 2004).

With respect to reducing process losses, scripts may be designed to take over arduous tasks not directly related to individual knowledge acquisition independent of learners' capabilities. Students may be well capable, for instance, of distributing responsibilities of sub-tasks or develop a schedule of who is doing what at what time. Scripts may, however, take over these organisational tasks and support learners to spend more time on the actual learning activities. There are indications that increasing time on task is a general effect of different types of scripts (Weinberger, Stegmann, Fischer, & Mandl, 2007). Given that learners generally adhere to script prescriptions, external scripts may reduce process losses also through harmonising different internal scripts. As internal scripts can be considered as culturally shared procedural knowledge, learners of one culture may carry similar internal scripts. Collaborative learners from different cultures may, however, particularly benefit from following external script prescriptions (Weinberger, Häkkinen, Clark, Tamura, & Fischer, 2007).

With respect to the university lecture example, the script may be designed to first make explicit to the students that they are expected to construct arguments and thus acquire important argumentative knowledge. The script may further contain a task schedule to reduce process losses and facilitate the construction of arguments, e.g., by providing learners with an interface in which messages are titles arguments, counterarguments and syntheses by default (see Stegmann et al., in press).

2. SPECIFICATION, FORMALISATION, DESIGN, AND DEPLOYMENT OF CSCL SCRITPS

Much of the research on scripts has been accomplished in the context of European CSCL research, in which the script approach has had a major impact over the last few years (CSCL Alpine Rendez Vous, 2007; Fischer et al., 2007). The CSCL context poses specific difficulties that scripts address, e.g., learners being at loss of what to do in complex CSCL environments. There are notions that unstructured, problem-based CSCL environments are too demanding for learners to actually benefit from them more than from traditional instruction (cf. Kirschner, Sweller, & Clark, 2006). Comparing individual and collaborative learners supported or not by a script, it was found that collaborative learners surpass individual learners only if they are supported by a script (Weinberger, Stegmann, & Fischer, 2007b).

The script approach has been at the crossroads of several research and development fields and has attracted special attention, especially in the e-learning community, although some times under different terminology. Approaches such as Educational Modelling Languages (EML) in instructional design (Learning Technology Standards Observatory, 2007), workflows in business processes (Vantroys, & Peter, 2003), or patterns and visual languages (Botturi, & Stubbs, in press) share many ideas, trends and proposals with the CSCL script approach (Vignollet, David, Ferraris, Martel, & Lejeune, 2006). Such a confluence raises the need to take advantage of all previous and current related work, merge these perspectives, and converge to a stable and widely accepted solution for all stakeholders (researchers in education, psychology and engineering, together with educational practitioners, or even technology and service providers).

In the university example, the teacher faces the problem of how to put into practice all the ideas for a script in a short term, without an excessive effort taking into account limited time availability and experience in technology enhanced environments. Thus, the teacher needs to consider the widely adopted Learning Management System (LMS), which has a strong support by the university administration, and an EML, which allows expressing the main characteristics of the script. In addition, the script should be easy to describe and design in common language based on established knowledge or innovative approaches towards collaborative learning.

2.1 Lifecycle and framework for CSCL scripts

Considerations such as the ones arising in the university lecture example of specifying and designing scripts drive many current efforts, which aim to provide scientific and technological support different phases of the lifecycle of a CSCL script. The integrated framework proposed by the European Research Team CoSSICLE (Computer-Supported Scripting of Interaction in Collaborative Learning Environments; Kobbe et al., in press) allows understanding and specification of components and mechanisms, i.e. the elements and procedures that are necessary for study and research on CSCL scripts. The formalisation of such a framework in computational terms opens the path for the use of computer-based tools for modelling and design of the scripts, while on the other hand it enables the interpretation and execution of such scripts in CSCL environments.

Formal expressions in terms of a computational language disambiguate the specified components and mechanisms. This is prerequisite to adapting scripts in different learning environments, i.e. to avoid the proliferation of ad-hoc implementations that are hardwired in a specific system. There is a practical need for a specification and formalisation of scripts to provide teachers and designers of collaborative learning environments with a script toolbox, dynamically adapt scripts during phases of collaborative learning, and make scripts transferable from one learning environment to another (see figure 2).

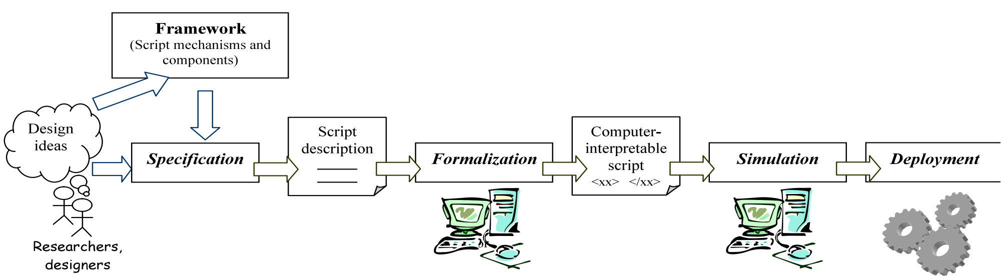

Figure 2: Lifecycle and its technology support for CSCL scripts

University teachers may be supported by tools for the conception and delivery of scripts in a general purpose LMS or a specific CSCL environment. Besides the individual university teacher, instructional designers may be more productive in the setup of similar environments, creating a community of teachers who exchange and tailor scripts, data and tools for their classes. It is then possible to expect a wider adoption of the CSCL script approach, taking into account the needs of all stakeholders and providing the appropriate support.

In the CoSSICLE framework, a stratified approach has been adopted to specify scripts, differentiating between schemata and families. While schemata follow some general design principles, script classes are variations of schemata prototypes that are adapted to the specific educational context, i.e. to the extrinsic constraints, while they comply with the script intrinsic constraints (Dillenbourg, & Tchounikine, 2007). Similarly to a pattern-based approach (Hernández-Leo, 2007), this framework builds on existing knowledge that is widely adopted by practitioners, while it is based on extensive educational research. Its main advantage lies in the flexibility that is provided to the practitioner or educational designer, since he can properly instantiate schemata and families, and facilitate specific interaction patterns that are best suited for specific scenarios.

Different script schemata have been identified (Dillenbourg, & Jermann, 2007) such as those that refer to *jigsaw* grouping and re-grouping learners with complementary knowledge (Aronson, Blaney, Stephan, Sikes, & Snapp, 1978), *conflict* grouping learners of contradictory knowledge and roles (e.g., Weinberger et al., 2005), and *reciprocal* facilitating questioning and tutoring activities (King, 2007). Similarly, collaborative learning flow patterns, such as jigsaw, pyramid, think-pair-share, etc. have been detected and included in the pattern oriented framework that supports similar levels of abstraction and specialisation (Hernández-Leo, Harrer, Dodero, Asensio-Pérez, & Burgos, 2006).

Additional to general script schemata and more specialised script classes, a structural decomposition is specified in the CoSSICLE framework, i.e. a minimal number of elements that cover the needs of a CSCL script. While scripts can be broken down to *components*, the dynamic and distributed character is defined through *mechanisms*. With respect to components, *roles* for example are supposed to facilitate specific collaborative learning *activities*, e.g., question asking, explaining, or finding evidence (see King, 2007). On the other hand, *participants* in the activities may form groups (e.g. expert and super groups in the jigsaw script class) and use computer and network resources, which may be offered as services (e.g. a shared workspace), although individual activities and non-ICT (Information and Communications Technologies) resources are also considered. The dynamic mechanisms that govern CSCL scripts include *task distribution* among groups and roles, *group formation* and *sequencing* of activities. It is noteworthy, that many instances of scripts classes can be described through a small set of components and mechanisms. For example, the specific *group formation* and rotation of *roles* are characteristic of the jigsaw script class fostering homogeneous participation in complementary learning activities.

2.2 Languages and tools for modelling and deployment

The selection of a formal language for the representation of a CSCL script is a crucial aspect, since this modelling language has to be sufficiently expressive for collaborative situations as well as compliant to standards. The general approach of EML, as e.g. IMS-LD (IMS, 2003), does not take into account all specific characteristics of CSCL while it suffers various deficiencies in terms of expressiveness (Caeiro-Rodríguez, Anido-Rifón, & Llamas-Nistal, 2003). However, a de-facto standard supported by international organisations motivates independent service providers to create tools that support the whole lifecycle, and therefore promotes the creation of sustainable technological solutions. Thus, an important dilemma has drawn the attention of researchers and developers in this field, i.e. whether using a proprietary language that allows for a richer, more precise and more efficient formalisation of CSCL scripts, or adopting a standard but probably insufficient language such as IMS-LD. Although a specialised language for CSCL scripts may coexist, there is a clear trend and need for a solution based on standards that may offer the option for gateways to specific solutions, or paths for future enrichment. Then, there is a chance for a wider adoption by the broad technology-enhanced learning community and hopefully by the educational practitioners, in the direction of solutions based on standards and open-source (Slotta, & Aleahmad, in press) in the general CSCL field.

Tools and computer-supported environments are the last elements that have to be provided and considered with respect to the technological support to the CSCL script lifecycle. For example, an editor is necessary for a researcher, instructional designer or educational practitioner in order to be able to define the components and mechanisms that formally describe a CSCL script in a computational language. For instance, the Collage editor (Hernández-Leo, et al, 2006) allows customisation and generation of hierarchical combinations of collaborative learning flow patterns (script classes), such as jigsaw or pyramid, represented in IMS-LD. An extensive multi-case study (Hernández-Leo, 2007) has shown that educational practitioners are able to successfully formulate their scripts in their specific contexts. An additional element of the CSCL script toolbox points to a simulator which allows designers to run their scripts in a simulated environment and then be able to reformulate them for a more effective and error-free implementation class environment (Harrer, 2006). Also, players are necessary to interpret the CSCL scripts that were designed and modelled, such as Coppercore for IMS-LD. Finally, computer architectures are useful to embed CSCL scripts in existing computer-supported learning environments, such as the Remote Control Approach (Harrer, Malzahn, &

Roth, 2006) or to enable tailoring of CSCL scripts using available tools offered as services, such as Gridcole (Bote-Lorenzo, et al., 2007).

In the university lecture example, the teacher may decide to use the jigsaw script schema depending on the respective educational objectives. Then, the basic script components and mechanisms employing the concepts of the previously mentioned CSCL framework can be specified, as e.g. define an *activity* for a final exchange of arguments between the members of the supergroups that were formed beforehand by the teacher, using the *resource* of an online argumentation forum integrated in a popular LMS. An editor could then be used to formalise the script and produce a machine-interpretable file, eventually in standard EML. Before the deployment of the script, the teacher may detect any eventual problems and reflect on the structure and performance of the script through the use of the simulator that is available. Finally, an interpreter integrated in a general-purpose LMS may bring the script in the class, with a possibility for a dynamic adaptation, as well as an eventual fading out of the external script.

Notably, teachers may pose substantially different requirements then researchers. While researchers may focus on studying adaptively fading script components in and out depending on learners' individual needs and deficits, practitioners or administrators are more interested in effectively and efficiently bringing these proposals in the real classroom with certain guarantees for sustainability and scalability. A solution to this dilemma may be of crucial importance that may drive the research and development roadmap in this field.

3. DISCUSSION AND OUTLOOK

When considering that collaborative learning is partly about adapting and modifying learners' internal scripts, external scripts may provide too little appeal to being internalised. Instead, scripts focus learners on their specific instructions. As a result and depending on the specific script type, learners may, for instance, reply to script prompts rather than learning partners or may disregard solving the task in favour of specific social activities or group formation activities. Apparently, scripts need to be adapted to the individual needs of the collaborative learners on multiple dimensions. Otherwise scripts may be ignored in the best case, but could be expected to have harmful effects in most cases (Mäkitalo, Weinberger, Häkkinen, Järvelä, & Fischer, 2005). Given modelling and design tools that support the deployment and adaptation of scripts, analysing learners' internal scripts and adapting external scripts accordingly or making scripts adaptive seems to be a feasible approach to this problem. Script components could be faded in or out according to the identified learners' needs or its actual effects on the collaborative process. Then again, scripts are entire procedures and may loose their actual instructional meaning when being technically described and broken up into single components.

One of the challenging issues in instructional design of CSCL scripts is to better integrate scripts into wider social planes such as overall classroom activities. Regardless of the technical learning platform applied - if any - the specification and formalisation of scripts can augment the use of scripts in the classroom. Technical descriptions of scripts realised with specific script modelling tools can not only preserve and convey the underlying educational principles of scripts, but also facilitate teachers to realise and orchestrate scripts of different granularities within their classroom. This includes, for instance, orchestration of individual and collaborative learning phases as well as identification of the role of the teacher within a wider classroom script.

However, it seems that there are several limitations in the use of scripts in authentic classroom contexts that lay out steps for future educational research. On one hand, scripts do not take into account learners' already existing scripts and scripts might capture learners' attention differently than it is expected. On the other hand, scripts can neither predict students' changing individual nor group needs. In order to offer meaningful support on time it is important to track the real-time processes so that scripts can fade in or out if necessary. A promising approach is to analyse processes in real-time. Tools for automatic analysis of natural discourse corpora offer a promising approach to this problem (Dönmez et al., 2005). Additionally, longer-term follow up studies in research on collaboration scripts can identify how fading scripts can facilitate students to become self-regulated learners.

With a few notable exceptions, the social and emotional aspects of collaboration have attracted less attention than its cognitive features (Crook 2000). However, there are many studies arguing that a sense of community and an open and sensitive atmosphere are necessary preconditions of collaborative learning (Cutler 1995; De Jong, Kollöffel, Van der Meijden, Kleine Staarman, & Janssen, 2005; Rourke & Anderson 2002; Rovai 2000; Wellman 1999). A strong mood of group togetherness can enhance the flow of information, the availability of support, commitment to group goals, and satisfaction with group efforts (Wellman 1999). De Jong and his colleagues (2005) consider that in order to establish and maintain a secure and collaborative atmosphere, learners should give precise expression not only to ideas and knowledge but also to social and affective propositions. Scripts can be seen as situational and contextual resources in learning environments (Häkkinen & Mäkitalo-Siegl, 2007) that can affect learners' motivation.

Therefore, research on learners' goals when using scripts might help us to understand in what ways scripts can also affect student's and group's goals and whether scripts can contribute to changing these goals in addition to changing internal scripts and knowledge.

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