Effects of Computer-Supported Collaboration Scripts on Domain-Specific and Domain-General Learning Outcomes: A Meta-Analysis

Freydis Vogel, Ingo Kollar, Frank Fischer, Ludwig-Maximilians-Universität München, Leopoldstr. 13, 80802 München, Germany
freydis.vogel@psy.lmu.de, ingo.kollar@psy.lmu.de, frank.fischer@psy.lmu.de

Abstract: CSCL scripts are an effective approach to structure collaborative learning processes in a beneficial way and herewith to foster learning outcomes in various domains. As the amount of research on CSCL scripts grows, it is the right time for a meta-analytical integration of the results. Using a random effects model, this meta-analysis integrated effect sizes of 19 comparisons derived from 13 studies about CSCL scripts. The average effects of CSCL scripts on domain-specific as well as domain-general learning outcomes were estimated. Additionally the meta-analysis targeted the role of additional content support as a potential moderator. Results indicate that CSCL scripts have moderate effects on learning outcomes while additional content support positively influences the effectiveness of CSCL scripts on domain-specific learning outcomes.

Introduction
Collaboration scripts for computer-supported collaborative learning (CSCL scripts) are used to support learners’ acquisition of domain-specific knowledge and domain-general skills (Kollar, Fischer, & Hesse, 2006). As learners are often not spontaneously able to engage in a deep elaborative dialogue while learning collaboratively (Cohen, 1994), collaboration scripts may be used to guide students through a meaningful and beneficial collaborative learning process which may result in deeper individual learning compared to unstructured collaboration (King, 2007). In CSCL scripts, the guidance usually is implemented by distributing roles and activities among the students as well as by sequencing of activities and role switches (Kobbe, et al. 2007).

Over the last years a variety of CSCL scripts have been developed and also to some extent been analyzed in empirical studies. In these studies the distribution of roles and activities is mostly implemented in an explicit way by means of assigning and introducing roles directly to the learners (e.g. Ertl, Reiserer, & Mandl, 2005; Schellens, Van Keer, De Wever, & Valcke, 2007) and requesting the learners to perform specific activities that are attached to these roles (e.g. Weinberger, Stegmann, & Fischer, 2010). Sometimes, roles are also induced in an implicit way by creating resource interdependence through the distribution of complementary material among the collaborators (e.g. Molinari, Sangin, Dillenbourg, & Nussli, 2009). Further, CSCL scripts may group learning partners in a way that takes advantage of differences in their prerequisites, e.g. their previous knowledge or their individual attitudes, as proposed by Dillenbourg and Hong (2008). When considering the variety of empirical studies, it also becomes obvious that CSCL scripts have been used in a broad range of domains which provide the content of the domain-specific knowledge the learners are supposed to acquire. The domains range from biology (e.g. Hron, Hesse, Reinhard, & Picard, 1997) over philosophy (e.g. Pfister, Mühlpfordt, & Müller, 2003) to psychology (e.g., Ertl, Kopp, & Mandl, 2006).

Beyond domain-specific knowledge, some studies also aim at learners’ acquisition of domain-general skills. In this meta-analysis, domain-general skills are understood as the learners’ capability to handle script-immanent mechanisms, such as the construction of arguments when a CSCL script guides learners through the sequence of argumentation (e.g. Weinberger et al., 2010). Since CSCL scripts typically have learners repeatedly carry script-immanent mechanisms out, we assume that these mechanisms will be automatized and internalized by the learners so that internal scripts (Kollar, Fischer & Slotta, 2007) are gradually developed (Schank, 1999).

In addition, some studies use multi-factorial designs that compare collaboration scripts with other forms of instructional support, more precisely additional content support like content schemes (e.g. Kopp, Ertl, & Mandl, 2006). By definition, CSCL scripts structure interactions on a content-free level and do not give any support regarding the learning content. Yet, learners might also require support to structure the learning content in a meaningful way in order to benefit from the collaborative learning process. Therefore, it is worthwhile to analyze if additional content support can advance the effectiveness of the use of CSCL scripts.

Since research on CSCL scripts has been flourishing over the past few years, the time seems right to provide a statistical meta-analysis that integrates the results of the different studies and analyzes the effects of learning with collaboration scripts in CSCL settings on learners’ domain-specific knowledge and domain-general skills, summarizes the single effects by estimating average effect sizes, examines the impact of additional content support as moderator, and critically discusses the effectiveness of the approach. To provide such a statistical meta-analysis is the main purpose of this paper.
This meta-analysis is concerned with three research questions regarding the effects of collaboration scripts in CSCL settings on learning outcomes that have been reported in previous studies.

R1 What is the mean effect of CSCL scripts on the acquisition of domain-specific knowledge, compared to unstructured CSCL, and to what extent are the integrated effects homogeneous?

Collaboration scripts usually aim to induce deeper elaboration of domain-specific learning material and herewith foster the acquisition of domain-specific knowledge. Thus, we hypothesize a positive effect of CSCL scripts on domain-specific knowledge compared to unstructured CSCL. As the realizations of the CSCL scripts differ between the included studies in a broad range, a rather high heterogeneity of the effects of CSCL scripts on domain-specific knowledge is expected.

R2 What is the effect of combining CSCL scripts with additional content support on domain-specific knowledge acquisition?

Collaboration scripts only provide support for collaborative interactions, i.e. they lack content-specific support. The additional use of content support could pre-structure the content of the learning material, so that learners are better capable to examine the material in the way suggested by the script and herewith benefit more from the use of a script regarding their domain-specific knowledge. Therefore, we hypothesize that the use of additional content support maximizes the effect of CSCL scripts on learners’ domain-specific knowledge.

R3 What is the mean effect of the use of CSCL scripts on the acquisition of domain-general skills compared to unstructured CSCL, and to what extent are the integrated effects homogeneous?

As collaboration scripts provide learners with the opportunity to repeatedly practice script-immanent domain-general activities, a positive effect of CSCL scripts on domain-general skills is expected as compared to unstructured CSCL. Also for the effects of CSCL scripts on domain-general skills we expect a rather high degree of heterogeneity.

Method

Criteria for Inclusion

All studies that were included in this meta-analysis met the following requirements:

1. Method: Only empirical studies investigating the effects of at least one experimental condition that involved the use of a collaboration script in a between-subjects design were included in this meta-analysis. In order to distinguish collaboration scripts from other kinds of instructional support, the term “script” had to be used by the author(s).

2. Dependent variable: To be included, at least one dependent variable needed to be a measure of a learning outcome (domain-specific and/or domain-general) with corresponding parameters reported.

3. Domain: The study needed to be conducted in a CSCL context.

4. Source: To reach a high quality standard, only studies that were published in peer-reviewed journals were included.

5. Language: Only studies written in English or German were included.

6. Sample: For each sample of data only the effects of one published study could be included. If more than one study reported findings based on identical data from an identical sample, only the study reporting the most precise data was included.

Sample of Included Studies

To attain a substantial sample of studies, two steps of data collection were conducted. In the first step data were collected by searching for relevant studies in three different bibliographical databases (OvidSP, ISI and ERIC, all with the same search terms, Boolean operators and search properties ((collaborat* OR cooperat*) AND (computer* OR CSCL) AND (script* OR scaffold* OR structur*) AND learn*)) within the search fields Title, Abstract, or Keywords. The database search provided an amount of 242 articles. After scanning title and abstract of each article, 122 articles could be identified as being unrelated to CSCL (e.g. articles about scripts in Theater Arts). By reading the remaining articles we filtered 45 articles which were classified as relevant as they were concerned with collaboration scripts in a computer-supported learning setting. In a second step, additional 14 relevant articles were found by scanning the reference lists of the 45 relevant articles.

After inspection of the 59 relevant articles, 46 of them had to be excluded due to one or more criteria for inclusion being violated. Finally, the sample for this meta-analysis includes 13 articles that met all criteria for inclusion. In summary, 1563 learners participated in the studies that are reported in these 13 articles.
Variables
This meta-analysis includes three different variables that were coded from the primary studies. As the focus lies on the effects of collaboration scripts on learning outcomes, each primary study provides at least one measure of domain-specific knowledge or domain-general skills. If more than one measure for the assessment of a variable was given, the most general measure was selected to be included into the meta-analysis in order to achieve the most comparable measures (e.g. if the measure for domain-specific knowledge consisted of one test asking broadly for concepts within the whole domain and a second test asking for knowledge about a very specific topic within the domain, the first test would have been selected). Finally, for each sample that was derived from the primary studies the presence of additional content support was coded. In the following, the single variables are described in more detail.

Domain-specific knowledge: As domain-specific knowledge, all outcomes were used which assessed learners’ domain-specific knowledge in a post-test administered after the intervention. The assessment could have been done in an open or closed format and should aim at the knowledge that students were expected to acquire within the domain the CSCL setting was designed for.

Domain-general skills: As indicators for domain-general skills, all variables were selected that assessed learners’ domain-general skills in a post-test accomplished after the intervention. To count as domain-general skills, the used tests were required to aim at knowledge about mechanisms suggested by the script. For instance, this could be knowledge about aspects of good collaboration or knowledge about the construction of argumentation sequences if the script aimed to structure related activities within the collaborative learning process.

Additional content support: Some studies reported a multi-factorial design which analyzed the effect of collaboration scripts in combination with a content support (e.g. content schemes, content-related scaffolds). In this case, the studies delivered two different sub-samples, which could be integrated into the meta-analysis. For each sub-sample included into the meta-analysis, the presence of additional content support was coded.

Statistical Analysis
As estimation for the single effect sizes of the primary studies, the unbiased estimate as proposed by Hedges (1981), also “called Hedge’s g” (Borenstein, Hedges, Higgins, & Rothstein, 2009, p. 27) was used. To estimate the average effect size \( d \) by integration of the single effects, the random-effects model (Borenstein, et al., 2009, pp. 69ff) was used because the features of the studies and the kind of measures for the variables varied between the studies and a common true effect size for all studies could not be assumed.

Results
Research Question 1: Effects of CSCL Scripts on Domain-Specific Knowledge
To estimate the average effect of CSCL scripts on the acquisition of domain-specific knowledge (compared to unstructured CSCL), 19 single effect sizes derived from the 13 selected primary studies were integrated. The integration yielded a moderate estimated average effect (\( d = 0.36; SE = 0.09; CI_{90\%} = [0.21; 0.51]; p < .01, \text{one-tailed} \)). As hypothesized, a positive effect of CSCL scripts on domain-specific knowledge compared to unstructured CSCL occurred. Regarding the analysis of heterogeneity of the true effect sizes of CSCL scripts on domain-specific knowledge, as hypothesized, there was considerable variation between the integrated studies with a moderate proportion of real variation within the observed variance (\( Q(df = 18) = 31.05, p < .01, F = 0.24, F^2 = 42\% \)). As there is a substantial amount of unexplained variance between the integrated studies, it is worthwhile to investigate which moderators are appropriate to explain this heterogeneity.

Research Question 2: Effects of Combining Content Support with CSCL Scripts
To analyze the impact of additional content support on the effects of CSCL scripts on the acquisition of domain-specific knowledge, two subgroups were formed out of the single effect sizes already reported in RQ 1 representing samples with vs. without additional use of content support. As hypothesized, the estimated average effect of CSCL scripts in the subgroup with additional content support (\( d = 0.59; SE = 0.16; CI_{90\%} = [0.32; 0.86]; p < .01, \text{one-tailed} \)) outperformed the estimated effect of CSCL scripts in the subgroup without additional content support (\( d = 0.12; SE = 0.16; CI_{90\%} = [-0.15; 0.39]; \text{n.s., one-tailed} \)) significantly with a difference of \( d_{\text{diff}} = 0.47 (SE = 0.23; Z_{\text{diff}} = 2.01; p < .05, \text{one-tailed} \)).

Research Question 3: Effects of CSCL Scripts on Domain-General Skills
Effects of CSCL scripts on domain-general skills were reported in four out of the 13 selected primary studies. To estimate the average effect on domain-general skills, a total of seven single effect sizes derived from the four studies were integrated. As hypothesized, the effect of CSCL scripts compared to unstructured CSCL is positive with a large estimated average effect (\( d = 1.07; SE = 0.25; CI_{90\%} = [0.66; 1.47]; p < .01, \text{one-tailed} \)). Regarding the analysis of heterogeneity of the true effect sizes of CSCL scripts on domain-general skills, the statistics also
point to a considerable amount of variation between the integrated studies with a moderate to high proportion of real variation within the observed variance ($Q(df = 15) = 15.26, p < .01, I^2 = 50\%, F = 61\%$), as hypothesized.

**Discussion**

Generally, the results of this meta-analysis support our hypotheses that CSCL scripts exert positive effects on specific learning outcomes when compared to unstructured CSCL. Regarding the first research question the results indicate that CSCL scripts on average provide more substantial support for learners’ domain-specific knowledge acquisition than unstructured CSCL. This, it can be presumed that CSCL scripts stimulate collaboration processes which are beneficial for domain-specific learning (Illenbourg & Hong, 2008; Rummel, 2007). Additionally we found quite a high variance of the true effect sizes between studies. This finding shows that there is still a considerable amount of variance left between the integrated studies that cannot be explained by the CSCL scripts. To investigate which variables might explain the remaining variance and moderate the effects, further analyses like the comparison of subgroups that was addressed by RQ 2 are required. The analysis of the impact of additional content support on the effect of CSCL scripts on domain-specific knowledge revealed a positive effect compared to CSCL scripts that are not combined with content-related support. Therefore, the use of additional content support strengthens the effects of CSCL scripts on learners’ domain-specific knowledge. It may thus be suggested that learning with CSCL scripts can be enhanced by the supplement of additional content support appropriate to the targeted domain.

As hypothesized, the meta-analysis also revealed a large positive average effect of learning with CSCL scripts on learners’ domain-general skills, compared to unstructured CSCL. The repeated practice of script-immanent mechanisms should have led to internalizing and automatizing the script (Schank, 1999). This finding supports the approach of using CSCL scripts to foster the acquisition of skills specified within the script itself. This approach is primarily reasonable when the script triggers skills meant to be internalized (e.g. argumentation). Most studies that reported findings on domain general skills, used CSCL scripts for argumentation (e.g. Borenstein et al. 2009; Stegmann et al. 2007; Rummel et al. 2010). This limits the external validity of the finding to some extent. It would be desirable if further studies investigating effects of CSCL scripts on domain-general skills would focus also on other learning-relevant processes beyond argumentation.

High variances of the true effect sizes between the integrated studies were found for the effects on domain-specific knowledge and domain-general skills. Therefore, it can be assumed that the different CSCL scripts used in the integrated studies vary in their impact on learning outcomes due to their distinct features. Consequently, further meta-analytical investigation should focus on the identification of features within the CSCL script studies that might moderate the strength of their impact on learning outcomes.

The limitation of this meta-analysis lies in its rather strict criteria for inclusion. Certainly, a less strict set of criteria would lead to a larger amount of studies that could be integrated (e.g., studies investigating instructional interventions similar or equal to CSCL scripts that are not labelled as such; e.g. Repman, 1993; Stri bos, artsens, schemons, & Broers, 2007). Also, studies that are concerned with CSCL scripts without analyzing domain-specific learning outcomes (e.g. Ertl, et al., 2006; Koll, et al., 2007; Spada, & Hauser, 2009; Schoonenboom, 2007) could be integrated into an enhanced meta-analysis. In addition, several qualitative studies and case studies could not be integrated into this meta-analysis, although they might help to reach a deeper understanding of how CSCL scripts work (e.g. Hilmnen & Arva, 2009). Further research should try to find ways to further integrate research on CSCL scripts. From our perspective, this meta-analysis can serve as a starting point for such efforts.

**References**

References marked with an asterisk (*) indicate that studies were integrated in the meta-analysis


