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The Role of Content Support and Transactivity for Effects of Computer-Supported Collaboration Scripts on Domain-Specific Learning: A Meta-Analysis

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***Abstract*—Scripts for computer-supported collaborative learning (CSCL scripts) usually provide just-in-time support for learners to engage in a meaningful collaborative learning process that eventually leads to domain-specific learning. In contrast, CSCL scripts are often criticized to hamper the naturally emerging processes in collaborative learning, and research about the effectiveness of CSCL scripts has shown divergent results. Therefore, this paper reports a meta-analytical integration of k = 33 effects on domain-specific learning that have been reported in recent research about CSCL scripts. Results show that on average CSCL scripts actually support the engagement in meaningful collaborative learning processes leading to a positive effect on domain-specific learning outcomes compared to unstructured collaborative learning (d = 0.20, p = 0.02). Further analyses show that the effectiveness of CSCL scripts can be increased by combining them with domain-specific content scaffolds and by designing them in a way that might induce transactivity (i.e. activities by which learners refer to their learning partners' contributions). Limitations and implications of this meta-analysis are discussed.**

I. INTRODUCTION

Collaborative learning is ascribed high potential for the learner's cognitive development. Research about collaborative learning reports a spectrum of different collaborative learning processes which have been found to be beneficial for learning [1], [2]. However, learners often have problems to spontaneously engage in these beneficial collaborative learning processes [3], [4]. To overcome these problems, learners can be facilitated by means of collaboration scripts which guide learners through a collaborative process that is beneficial for learning. By implementing such scripts in a computer-supported learning environment learners can be supported just-in-time when they need to know which step to do next in a specific collaborative learning process [5]. CSCL scripts are designed as scaffolds that sequence activities and distribute them among several roles that are assigned to the collaborating learning partners [6] to stimulate collaborative activities that are beneficial for learning [7], [8].

A variety of CSCL scripts have been developed and analyzed in empirical studies [9], [10], [11], [12], [13], [14], [15], [16]. Despite a broad agreement about the potential of CSCL scripts to enhance collaborative learning, the studies report heterogeneous results regarding the effect of CSCL scripts on domain-specific learning outcomes [17], [13], [16] [18]. This raises the question which factors in learning with CSCL scripts might influence the effects of CSCL scripts on domain-specific learning outcomes. Yet, systematic research about moderators which could possibly reduce or increase the effectiveness of CSCL scripts can hardly be found. One moderator might be the degree of content-related support that is additionally provided in experimental studies about CSCL scripts. On the one hand CSCL scripts are typically designed to be content free. On the other hand learners might also need support with respect to content in order to perform the activities induced by the script in a meaningful way [19], [20]. Another worthwile moderator is based on the specific collaborative learning processes that might be induced by a CSCL script. Within a collaborative learning process, transactive activities (i.e. activities that relate to the learning partners' contributions) are assumed to be most effective for learning [21], [22]. Also, CSCL scripts have the potential to induce transactivity which might lead to best learning outcomes [23], [13].

Against this backdrop, this study presents a meta-analysis (1) to investigate the general effects of CSCL scripts on domain-specific learning outcomes and (2) to examine to what extent the degree of content-related support and transactivity moderate the effectiveness of CSCL scripts.

A. Fostering domain-specific learning with CSCL scripts

As it is the case for other social situations, learners develop internal scripts that incorporate learning strategies that are appropriate for certain collaborative situations [24]. In their *script theory of guidance,* Fischer et al. [23] refer to Schank's [24] theory of *dynamic memory* to describe how components of internal scripts are developed on different hierarchical levels of three types with increasing specificity (the play level, the scene level and the scriptlet level). Intersecting with the scene levels, scriptlets may also be organized in roles. To benefit from collaborative learning, learners must be able to use an internal

script which contains script components for activities that are beneficial for their own as well as their partners' learning. Examples of activities in beneficial collaborative learning processes are reciprocal questioning, explaining, or engaging in argumentation [7]. A large corpus of research about collaborative learning investigated the relevance of different collaborative activities for learning [26], [27]. Yet, learners are often not spontaneously able to engage in the beneficial collaborative learning activities [3]. This means that they often have only insufficient internal scripts about the structure and sequence of activities and roles in which they should engage [23]. Therefore, CSCL scripts are designed to provide support for performing activities that are not part of the learners' prior internal scripts for the learning situation in question. This in turn may result in better individual learning (i.e., more positive learning outcomes due to more functional learning activities) compared to unstructured collaboration [7]. CSCL scripts are based on distinct collaborative learning processes, which are assumed to be beneficial for domain-specific learning outcomes. For instance, some CSCL scripts scaffold peer feedback and assessement [28], others scaffold social-discursive argumentation [13] or good collaborative work [29].

In recent research different types of CSCL scripts have been developed to foster learning in various domains such as computer science [9], [11], economics [17], life sciences [13], educational science [16], or medicine and psychology [30]. To measure the domain-specific learning outcome, tests usually focus on learners' knowledge about domain-specific content (e.g., knowledge about a specific scientific theory).

B. Potential moderators for the effectiveness of CSCL scripts

This study investigates the role of two moderators which may possibly influence the effectiveness of learning with CSCL scripts: the degree of content-related support and the transactivity.

1) Degree of content-related support

Some studies about CSCL scripts combined the scripts with content-related scaffolds, for example, content schemes [19], computer-supported hyperlink scaffolds [9] or scaffolds for simulation-based inquiry learning [10]. Other studies about CSCL scripts provide only content-related information without any scaffold for processing the information (e.g. plain texts for reading about a theme which is relevant to the domain, [30]. In these studies the content-related infomration serves as knowledge resource. In yet other studies, no content-related support was provided at all during the collaborative learning [11]. From a theoretical perspective, the degree of content related support provided in addition to a CSCL script might have a positive impact on the effectiveness of this script. CSCL scripts foster interactions in terms of certain structural aspects. However, in order to benefit from the collaborative learning processes, learners might also require scaffolds which help them make use of the learning content in a meaningful way [20].

2) Transactivity

A second possible moderator influencing the effectiveness of CSCL scripts is the degree of inducing transactive activities of the learners [23]. Research about collaborative learning found transactivity to be the most beneficial collaborative learning activity for learning outcomes [21], [22]. In this research, collaborative learning activities are classified as transactive when learners take their learning partners' contributions into account by, for instance, advancing, criticising or revising their partners' contributions. Thus, it may be assumed that a CSCL script designed to stimulate transactivity might increase domain-specific learning outcomes compared to CSCL scripts which do not aim to induce transactivity [23]. The results of individual empirical studies about CSCL scripts which stimulate transactivity seem to support this assumed positive effect of transactivity [13].

C. Research questions

Given the diverse results reported in the research literature about CSCL scripts, the following research questions are raised:

(1) What is the effect of collaborative learning supported by a CSCL script compared to collaboration without such support on domain-specific learning outcomes?

(2) To what extent does the effect of collaborative learning supported by a CSCL script on domain-specific learning outcomes depend on the degree of content-related support?

(3) To what extent does the effect of collaborative learning supported by a CSCL script on domain-specific learning outcomes depend on the transactivity of the activities which the CSCL script is designed to stimulate?

With respect to RQ 1, we hypothesized a positive mean effect of learning with CSCL scripts on domain-specific learning outcomes as compared to collaborative learning without such support. With respect to RQ2, we expected a positive effect of additionally provided content-related support on the effectiveness of CSCL scripts on domain-specific learning outcomes, since the additional use of especially content-related scaffolds may pre-structure the learning material in a way that makes learners better capable to collaboratively examine it in the way scaffolded by the CSCL script [19]. Concerning RQ3, we expected that CSCL scripts mainly designed to induce transactivity will lead to the use of transactive activities during the collaborative learning process [13], and in turn have a higher effectiveness on domain-specific learning outcomes compared to CSCL scripts that are not mainly designed to induce transactivity.

II. METHOD

A. Criteria for Inclusion

Studies had to meet the following requirements for inclusion in this meta-analysis:

(1) Independent variable: Included studies had to manipulate the availability of a CSCL script. This is the case if activities and/or roles are distributed among a small group of learners by means of scaffolds in a computer-based environment [23], [8], [6]. To distinguish a CSCL script from other scaffolds that support individual learning, at least one of the induced activities must be addressed to one ore more learning partners

(explaining something to a learning partner, etc.). Further, learners have to use computers while learning with the script.
(2) Dependent variable. Studies had to report at least one quantitative measure for domain-specific learning outcomes for being included in the meta-analysis. All information required for estimating an effect size had to be available in the report.
(3) Source. Only studies that were published in peer-reviewed journals were included in the meta-analysis. Furthermore, studies were only included if the report was written in English.
(4) Duplicates. Publications based on studies that were more comprehensively reported in other publications based on the same dataset from the same samples of participants (duplicate publication) were excluded. Nevertheless, if such articles reported results concerning other variables, the information from the different publications was merged.

B. Selection procedure

1) Database search

A database search was conducted in two different bibliographic databases (ERIC and ISI Web of Science). In each of the two bibliographic database the following search strig was used: (script* OR scaffold*) AND (learn* OR know*) AND (collaborat* OR cooperat*) AND (computer* OR CSCL OR techno*). Search was limited to peer-reviewed academic journals, yielding a sample of 248 articles.

2) Assessment of relevance based on title and abstract

The titles and abstracts of the 248 articles were classified with respect to their relevance reflecting the first criterion for inclusion by two raters with a very good inter-rater reliability based on 19 double coded articles (Cohen's kappa = 1.00). The coding resulted in a first selection of 175 articles.

3) Assessment of relevance based on full texts

The full texts of the 175 articles from the first selection stage were inspected with respect to the further inclusion criteria by three coders. Each coder evaluated all 175 articles. Inter-rater agreement was acceptable (Fleiss' kappa = .722). The coders discussed each individual article for which there was any disagreement (i.e. 26 studies) until they reached a consensus about inclusion. This procedure led to a total of 21 articles that met all criteria for inclusion.

4) Description of the set of articles included

In summary, 2166 learners participated in the experiments that are reported in the 21 articles which were finally included in this meta-analysis. On average a mean age of 21.5 years was reported for the participants. The duration of treatments that were reported in the articles was about 200 minutes on average. The shortest treatment lasted 12 minutes while the longest treatment took about 24 hours.

C. Coding of study features

Each study was coded by one of three coders. For each of the following study features, their agreement was determined based on a random sample of the studies that were coded by all three coders independently of each other. In the following, their agreement based on these samples is reported along with the individual study features.

1) Coding of the independent variable: CSCL scripts

For each condition of the experiments reported in the articles, it was coded whether it represented an experimental condition (learning with a CSCL script) or a control condition (unstructured collaborative learning). Good interrater-agreement was achieved in a random sample of seven articles that reported 18 conditions (Fleiss' Kappa = 0.93). Non-experimental studies were not included in this meta-analysis.

2) Coding of the dependent variable: domain-specific learning outcomes

Each dependent variable that was reported in the studies was categorized as being either a domain-specific learning outcome or a measure of a different kind (e.g. pre-test measure, domain-general learning outcome, or a learning process measure). Sufficient inter-rater agreement was achieved for coding 42 individual measures that were reported in a random sample of four articles (Fleiss' Kappa = 0.79).

3) Coding of the potential moderators

To answer RQ2 and RQ3, each study was coded with respect to (1) which degree of content-related support was additionally provided in the learning arrangements and (2) whether the script aimed at inducing transactivity or not. Inter-rater agreement for these two moderators was satisfactory (see table 1).

D. Calculation of individual effect sizes

The unbiased estimate of the standardized mean difference between experimental and control conditions with pooled standard deviations across groups [31], [32] was used as the index of effect size.

TABLE I. DESCRIPTIONS AND INTER-RATER AGREEMENT FOR CODING THE MODERATORS CONTENT SCAFFOLD AND TRANSACTIVITY

Dimensions and codes	Description	ICC
Degree of content-related support		0.68
without content-related support	No content-related support is provided during treatment (no mention of any domain-specific content)	
content-related information available	Content-related information is available but the information is not structured by means of a scaffold (e.g., only readings about domain-specific content)	
with content-related scaffolds	Scaffolds are additionally provided to support the processing of content-related infomration (e.g., learners can browse through structured hyperlinks or a domain-specific worked example is given to the learners)	
Transactivity		0.82
low	The CSCL script is not designed to induce any transactive activities	
high	The CSCL script is designed to induce transactive activities	

For studies that reported findings for more than one domain-specific learning outcome, all relevant effect sizes were averaged. The corresponding within-study effect variance was calculated assuming an intercorrelation of 0.5 as described by Borenstein et al. [32], p. 228.

E. Statistical analysis

A random-effects model was assumed in synthesizing the study effects. To compare effect sizes of CSCL scripts between moderator levels, the mean effect sizes and their confidence intervals were calculated for each subgroup assuming random-effects models within moderator levels. To compare the effect sizes of the different subgroups, Q tests for heterogeneity were calculated [32]. The level of significance was set to 5% for all analyses.

III. Results

A. Mean effect of CSCL scripts (RQ 1)

To estimate the average effect of learning with CSCL scripts compared to unstructured collaborative learning on domain-specific learning outcomes, 33 single effect sizes derived from 21 articles were synthesized. The statistics pointed to a substantial between study variance $Q(df = 32) = 137.88$, $p = 0.02$, $I^2 = 77\%$) which warranted the further use of the random-effects model. To explain this variation among the individual studies' effects, the consideration of moderators in further analyses is indicated. As hypothesized, a positive and significant small average effect of CSCL scripts on domain-specific learning outcomes compared to unstructured collaborative learning was found ($d = 0.20$, $SE = 0.10$, $p = 0.02$).

B. Moderator analyses

1) The role of the degree of content-related support for the effectiveness of CSCL scripts (RQ 2)

In the first moderator analysis effect sizes for learning with CSCL scripts were compared between the three subgroups of without content-related support, with content-related information available and with content-related scaffolds. No statistically significant difference between the effect sizes of the three subgroups was found, $Q(df = 2) = 0.77$, $p = .68$. Descriptively, however, the mean effect of CSCL scripts in the subgroup with content-related scaffolds was highest and its difference from 0 was statistically significant ($d = 0.29$, $SE = 0.13$, $p = 0.01$), whereas the mean effects of CSCL scripts in the subgroups with only content-related information available ($d = 0.14$, $SE = 0.12$, $p = 0.12$) and without any additionally provided content-related support ($d = 0.18$, $SE = 0.29$, $p = 0.27$) were descriptively lower and both did not differ significantly from 0, see Fig. 1.

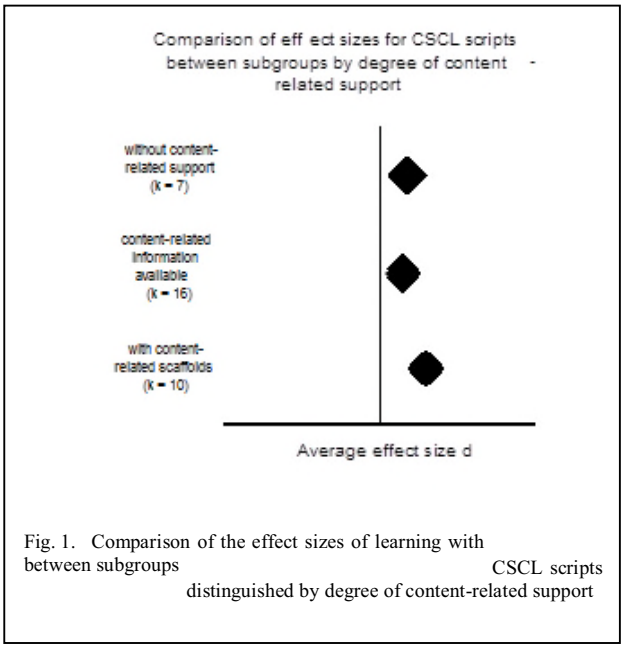

Fig. 1. Comparison of the effect sizes of learning with CSCL scripts between subgroups distinguished by degree of content-related support

2) The role of the transactivity a CSCL script is designed to induce for the effectiveness of CSCL scripts (RQ 3)

In the second moderator analysis the effects of CSCL scripts in the subgroup with high transactivitiy was compared to the subgroup with low transactivity. No statistically significant difference between the effect sizes of the two subgroups was found ($Q(\text{df} = 1) = 0.28$, $p = 0.60$). Nevertheless, CSCL scripts that did not aim at evoking transactive activites had descriptively a negligible positive effect on domain-specific learning outcomes that was not statistically significant ($d = 0.05$, $SE = 0.11$, $p = 0.43$). In contrast, CSCL scripts that were designed to induce transactive activities had a significant positive effect on domain-specific learning outcomes ($d = 0.22$, $SE = 0.10$, $p = 0.02$), see Fig. 2.

IV. Discussion

So far, research about scripts in computer-supported collaborative learning has shown divergent results regarding the effectiveness of CSCL scripts in terms of domain-specific learning outcomes [33], [34]. This meta-analysis was conducted to clarify the issue to what extent CSCL scripts lead to better domain-specific learning outcomes. The results indicate that on average CSCL scripts provide substantial support for learners' domain-specific learning processes. This CSCL scripts are likely to stimulate cognitive processes during collaboration which are beneficial for domain-specific learning [7].

The results also show that, for the support of domain-specific learning outcomes, the effectiveness of CSCL scripts can be increased when learners are additionally supported by means of content-related scaffolds for the domain they are supposed to learn about [19]. Since CSCL scripts are typically designed without any reference to specific content, additional content-based support may help learners to perform beneficial collaborative learning activities in a meaningful way that is conducive to domain-specific learning [20]. The result might be considered as a case of synergistic scaffolding [35]. It can be suggested that learning supported by CSCL scripts should be enriched with additional content-related scaffolds appropriate to the target domain in order to foster the acquisition of domain-specific knowledge. As there is still a significant amount of heterogeneity between the integrated

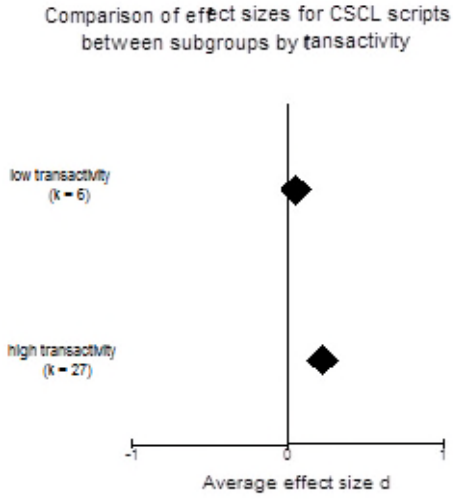

Fig. 2. Comparison of effect sizes of learning with CSCL scripts between subgroups distinguished by transactivity

studies within each subgroup we analyzed, in future research it would be worthwhile to investigate possible causes for this heterogeneity. For instance, different kinds of content-related scaffolds might produce diverse effects (e.g., worked-out examples; [36]). Also, it is still an open question how the two different kinds of scaffolds (i. e. CSCL scripts and content-related scaffolds) should be combined to lead to optimal results (i. e., synergy; [35]). Further research on the combination of CSCL scripts and content-related scaffolds might focus on questions concerning the optimal sequence and timing for both types of scaffolds [5].

Within collaborative learning processes, transactive activities are ascribed high potential to foster effective learning [21], [22]. In line with our hypothesis, the CSCL scripts that were designed with the intention to stimulate transactive activities had a larger positive effect on domain-specific learning outcomes than scripts that were not designed to stimulate transactive activities. Therefore, it seems advisable that CSCL scripts be designed in a way that stimulates the learners to take their parners' contributions into account (e.g. criticizing the learning partner's arguments, responding to questions, advancing the learning partner's contribution). It should be noted, however, that information about the extent of transactive activities the learners actually used when the CSCL script requested transactive activities, was not consistently available for inclusion in the present meta-analysis. The studies included in this meta-analysis only rarely provided a specific measure of the transactive activities in the learning process [37], [13]. To advance research on CSCL scripts, it would be helpful if in future studies transactivity was measured by a common procedure and always reported.

Several limitations of the present meta-analysis have to be taken into account. One limitation lies in the rather strict criteria for inclusion. Even though the criteria proved helpful for answering our research questions, a less strict set of criteria would possibly lead to a larger amount of studies to be integrated. It might be possible that there are still undetected studies about collaborative learning that is scaffolded by means of a CSCL script. Yet, these studies might have remained undetected because other terms but script or scaffold were used to describe the intervention. Another limitation is the operationalization of the two moderators. The coding of the moderators had to rely completely on what was reported in the reports about the primary studies, and the precision and comprehensiveness of these descriptions varies substantially between the publications. For the degree of content-related support, information was sometimes provided only incompletely and the estimation made for the degree of content-related support might be imprecise for at least a part of the included primary studies.

Furthermore, it must be mentioned that beyond the scope of this meta-analysis, there are many qualitative studies and case-analyses left that could not be integrated, although they would help to reach a deeper understanding about the mechanisms of CSCL scripts [38]. Also, a large amount of studies and conceptual articles about CSCL scripts could not be included in this meta-analysis, because they did not compare learning with CSCL scripts to unstructured collaborative learning in a (quasi)-experimental design [39], [40], or because they did not report measures for the target dependent variable of this meta-analysis [41], [42], [43].

In conclusion, this meta-analysis clearly supports the approach of using scripts in computer-supported collaborative learning settings to help learners acquire domain-specific knowledge and skills. Educators and designer of CSCL scripts should consider the combination of CSCL scripts with additional content-related scaffolds. Also, based on the results of this meta-analysis it can be recommended that CSCL scripts should be designed in a way that demands transactive activities (i.e. referring to the contributions of their learning partners) to support domain-specific learning in the most beneficial way. Yet, there are still open questions about how to tweak CSCL scripts, for instance, by inducing specific collaborative learning activities, by additionally providing specific content-related scaffolds (e.g. worked examples) in different domains, or by the design of the combination of CSCL scripts and content-related scaffolds. The results of this meta-analysis constitute a helpful starting point for further research about the design and the use of CSCL scripts.

REFERENCES

[1] S. Y. Kwon and L. Cifuentes, "The Comparative Effect of Individually-Constructed vs. Collaboratively-Constructed Computer-Based Concept Maps," Computers & Education, vol. 52, no. 2, pp. 365–375, Feb. 2009.

[2] N. M. Webb, M. L. Franke, T. De, A. G. Chan, D. Freund, P. Shein, and D. K. Melkonian, "'Explain to your partner': teachers' instructional practices and students' dialogue in small groups.," Cambridge Journal of Education, vol. 39, no. 1, pp. 49–70, Mar. 2009.

[3] G. C. Cohen, "Restructuring the classroom: 'Conditions for productive small groups.," Review of Educational Research, vol. 64, no. 1, pp. 1–35, 1994.

[4] D. Kuhn, V. Shaw, and M. Felton, "Effects of dyadic interaction on argumentative reasoning," Cognition and Instruction, vol. 15, no. 3, pp. 103–121, 1997.

[5] J. J. G. van Merrienboer, P. A. Kirschner, and L. Kester, "Taking the Load Off a Learner's Mind: Instructional Design for Complex Learning," Educational Psychologist, vol. 38, no. 1, pp. 5–13, 2003.

[6] I. Kollar, F. Fischer, and F. W. Hesse, "Collaboration scripts - a conceptual analysis," Educational Psychology Review, vol. 18, no. 2, pp. 159–185, 2006.

[7] A. King, "Scripting collaborative learning processes: A cognitive perspective," in Scripting computer-supported collaborative learning - cognitive, computational, and educational perspectives, F. Fischer, I. Kollar, H. Mandl, and J. M. Haake, Eds. New York, NY: Springer, 2007, pp. 13–37.

[8] L. Kobbe, A. Weinberger, P. Dillenbourg, A. Harrer, R. Hämäläinen, P. Häkkinen, and F. Fischer, "Specifying computer-supported collaboration scripts," International Journal of Computer-Supported Collaborative Learning, vol. 2, pp. 211–224, 2007.

[9] S. Demetriadis, T. Egerter, F. Hanisch, and F. Fischer, "Peer review-based scripted collaboration to support domain-specific and domain-general knowledge acquisition in computer science.," Computer Science Education, vol. 21, no. 1, pp. 29–56, März 2011.

[10] H. Gijlers and T. de Jong, "Sharing and Confronting Propositions in Collaborative Inquiry Learning," Cognition and Instruction, vol. 27, no. 3, pp. 239–268, 2009.

[11] J. M. Haake and H.-R. Pfister, "Scripting a distance-learning university course: Do students benefit from net-based scripted collaboration?," International Journal of Computer-Supported Collaborative Learning, vol. 5, pp. 191–210, 2010.

[12] I. Kollar, F. Fischer, and J. D. Slotta, "Internal and external scripts in computer-supported collaborative inquiry learning," Learning and Instruction, vol. 17, no. 6, pp. 708–721, 2007.

[13] O. Noroozi, S. D. Teasley, H. J. A. Biemans, A. Weinberger, and M. Mulder, "Facilitating learning in multidisciplinary groups with transactive CSCL scripts," International Journal of Computer-Supported Collaborative Learning, vol. 8, no. 2, pp. 189–223, 2013.

[14] N. Rummel, D. Mullins, and H. Spada, "Scripted Collaborative Learning with the Cognitive Tutor Algebra," International Journal of Computer-Supported Collaborative Learning, vol. 7, no. 2, pp. 307–339, 2012.

[15] T. Schellens, H. Van Keer, B. De Wever, and M. Valcke, "Scripting by assigning roles: Does it improve knowledge construction in asynchronous discussion groups?," International Journal ofComputer-Supported Collaborative Learning, vol. 2, pp. 225–246, 2007.

[16] K. Stegmann, A. Weinberger, and F. Fischer, "Facilitating argumentative knowledge construction with computer-supported collaboration scripts," Computer-Supported Collaborative Learning, vol. 2, no. 4, pp. 421–447, 2007.

[17] H.-W. Huang, C.-W. Wu, and N.-S. Chen, "The effectiveness of using procedural scaffoldings in a paper-plus-smartphone collaborative learning context," Computers & Education, vol. 59, no. 2, pp. 250–259, Sep. 2012.

[18] A. Weinberger, B. Ertl, F. Fischer, and H. Mandl, "Epistemic and social scripts in computer-supported collaborative learning," Instructional Science, vol. 33, no. 1, pp. 1–30, 2005.

[19] B. Ertl, B. Kopp, and H. Mandl, "Supporting learning using external representations," Computers & Education, vol. 51, no. 4, pp. 1599–1608, Dezember 2008.

[20] T. D. Sadler, "Informal reasoning regarding socioscientific issues: A critical review of research," J. Res. Sci. Teach., vol. 41, no. 5, pp. 513–536, 2004.

[21] M. T. H. Chi, "Active-Constructive-Interactive: A Conceptual Framework for Differentiating Learning Activities," Topics in Cognitive Science, vol. 1, no. 1, pp. 73–105, 2009.

[22] S. D. Teasley, "Talking about reasoning: How important is the peer in peer collaborations?," in Disourse, Tools, and Reasoning: Situated Cognition and Technologically Supported Environments, C. O'Malley, Ed. Berlin: Springer, 1997, pp. 361–384.

[23] F. Fischer, I. Kollar, K. Stegmann, and C. Wecker, "Toward a Script Theory of Guidance in Computer-Supported Collaborative Learning," Educational Psychologist, vol. 48, no. 1, pp. 56–66, 2013.

[24] R. C. Schank, Dynamic memory revisited. Cambridge, NY: Cambridge University Press, 1999.

[25] I. Choi, S. M. Land, and A. J. Turgeon, "Scaffolding peer-questioning strategies to facilitate metacognition during online small group discussion," Instructional Science, vol. 33, pp. 483–511, 2005.

[26] A. King, "Comparison of Self-Questioning, Summarizing, and Notetaking-Review as Strategies for Learning From Lectures," American Educational Research Journal, vol. 29, no. 2, pp. 303–323, Jun. 1992.

[27] D. Kuhn and A. Crowell, "Dialogic Argumentation as a Vehicle for Developing Young Adolescents' Thinking," Psychological Science, vol. 22, no. 4, pp. 545–552, Apr. 2011.

[28] M. H. Ulicsak, "'How did it know we weren't talking?': An investigation into the impact of self-assessments and feedback in a group activity," Journal of Computer Assisted Learning, vol. 20, no. 3, pp. 205–211, 2004.

[29] N. Rummel, H. Spada, and S. Hauser, "Learning to collaborate while being scripted or by observing a model," IJCSCL, vol. 4, no. 1, pp. 69–92, 2009.

[30] N. Rummel and H. Spada, "Learning to Collaborate: An Instructional Approach to Promoting Collaborative Problem Solving in Computer-Mediated Settings," Journal of the Learning Sciences, vol. 14, no. 2, pp. 201–241, 2005.

[31] L. Hedges, "Distribution theory for Glass's estimator of effect size and related estimators.," Journal of Educational Statistics, vol. 6, no. 2, pp. 107–128, 1981.

[32] M. Borenstein, L. V. Hedges, J. P. T. Higgins, and H. R. Rothstein, Introduction to Meta-Analysis. Chichester, UK: Wiley, 2009.

[33] G. Molinari, M. Sangin, P. Dillenbourg, and M.-A. Nüssli, "Knowledge interdependence with the partner, accuracy of mutual knowledge model and computer-supported collaborative learning," European Journal of Psychology of Education, vol. 24, no. 2, pp. 129–144, 2009.

[34] A. Weinberger, K. Stegmann, and F. Fischer, "Learning to argue online: Scripted groups surpass individuals (unscripted groups do not)," Computers in Human Behavior, vol. 26, no. 4, pp. 506–515, 2010.

[35] I. Tabak, "Synergy: A Complement to Emerging Patterns of Distributed Scaffolding," Journal of the Learning Sciences, vol. 13, no. 3, pp. 305–335, 2004.

[36] A. Renkl, "Learning from worked-out examples: a study of individual differences.," Cognitive Science, vol. 21, no. 1, pp. 1–29, 1997.

[37] A. Jeong and S. Joung, "Scaffolding collaborative argumentation in asynchronous discussions with message constraints and message labels," Computers & Education, vol. 48, no. 3, pp. 427–445, 2007.

[38] R. Hämäläinen and M. Arvaja, "Scripted collaboration and group-based variations in a higher education CSCL context," Scandinavian Journal of Educational Research, vol. 53, no. 1, pp. 1–16, 2009.

[39] P. Dillenbourg and P. Tchounikine, "Flexibility in macro-scripts for computer-supported collaborative learning," Journal of Computer Assisted Learning, vol. 23, no. 1, pp. 1–13, 2007.

[40] H. G. K. Hummel, J. van Houcke, R. J. Nadolski, T. van der Hiele, H. Kurvers, and A. Löhr, "Scripted collaboration in serious gaming for complex learning: Effects of multiple perspectives when acquiring water management skills," British Journal of Educational Technology, vol. 42, no. 6, pp. 1029–1041, 2011.

[41] U. Cress, K. Wodzicki, M. Bientzle, and A. Lingnau, "CSCL for intellectually disabled pupils: Stimulating interaction by using a floor control mechanism," International Journal of Computer-Supported Collaborative Learning, vol. 6, no. 2, pp. 307–321, Jun. 2011.

[42] T. Schellens, H. Van Keer, B. De Wever, and M. Valcke, "Tagging thinking types in asynchronous discussion groups: effects on critical thinking," Interact. Learn. Environ., vol. 17, no. 1, pp. 77–94, 2009.

[43] S. W. Yeh, J. J. Lo, and J. J. Huang, "Scaffolding collaborative technical writing with procedural facilitation and synchronous discussion," International Journal of Computer-Supported Collaborative Learning, vol. 6, no. 3, pp. 397–419, 2011.