When Instruction Supports Collaboration, but Does not Lead to Learning – the Case of Classroom and Small Group Scripts in the CSCL Classroom

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Abstract: Typically, instructional guidance for CSCL has two aims, namely to help students (a) collaborate on a higher level and (b) become more proficient in the practices that are facilitated during collaboration. This paper presents an empirical study in which high school students' collaborative online search behavior (as a learning process measure) as well as their online search competence (as individual learning outcome) were targeted by small group collaboration scripts and classroom scripts. Both the small group collaboration script and a plenary-plus-group level classroom script yielded positive effects on online search activities during collaboration. When no or just one scaffold was given, correlations between the quality of collaborative online search activities and individual online search competence (as learning outcome) were positive. When both interventions were combined, however, the correlation disappeared, indicating that although this combination helped students act on a higher level during collaboration, it did not contribute to individual learning.

Introduction and aims of the study

Numerous studies have demonstrated that to make CSCL effective, instructional guidance, e.g. through the provision of argument maps (Suthers & Hundhausen, 2003), group awareness tools (Buder & Bodemer, 2008) or collaboration scripts (Kollar, Fischer & Slotta, 2007), is necessary. The aim of such guidance typically is two-fold: first, it is meant to help learners collaborate on a higher level (e.g., by increasing the level of knowledge building activities; see Schellens, De Wever, van Keer & Valcke, 2007) than without guidance. Second, guidance also aims at helping students learn more, i.e. reach higher individual knowledge and skill levels measured after collaboration (see, for example, Weinberger, Ertl, Fischer & Mandl, 2005).

Sometimes, multiple sources of guidance are combined to reach these objectives. For example, Kollar et al. (2012) combined small group collaboration scripts with heuristic worked examples in a CSCL environment designed to acquire mathematical argumentation competence. Likewise, Kopp and Mandl (2011) used both a small group collaboration script and a content scheme to provide guidance in a case-based CSCL environment. Providing learners with several sources of instructional guidance typically has the aim to produce synergistic scaffolding effects (Tabak, 2004), i.e. that the potentially positive effects of the used scaffolds do not simply add up, but rather interact positively with each other, with the result that the effects of each scaffold are amplified by the simultaneous provision of the other. However, as research shows, combining scaffolds in a way that synergistic scaffolding occurs is difficult. For instance, Kollar, Wecker, Langer and Fischer (2011) showed that combining a small-group collaboration script guiding dyadic online search processes and a plenary-plus-group level classroom script (i.e., an instructional intervention that alternated the modeling of online search activities as plenary activities and dyadic online search phases as group level activities in the classroom) did not yield a synergistic scaffolding effect on the acquisition of online search competence. Although both interventions were effective when the other one was not provided, their combination did not affect the effectiveness of the small group collaboration script and even slightly reduced the effectiveness of the plenary-plus-group level classroom script. However, in the Kollar et al. (2011) study, no process-based explanation for this result was provided. Therefore, this paper aims at providing an analysis of collaborative online search activities that occurred in the Kollar et al. (2011) study and investigates how these collaborative online search activities relate to online search competence students displayed in a subsequent individual posttest.

Fostering online search competence as a grand challenge for education

To participate in societal debates about science-related issues (e.g., whether nuclear power plants should be shut down), members of the information society need to have well-developed strategies to find and use relevant and credible information. Much of this information is available on the Internet. Since anyone can publish on the Internet, however, credibility, lopsidedness, timeliness and relevance of information are critical issues. Thus, supporting learners in their development of online search competence is a grand challenge for education.

Gerjets, Kammerer and Werner (2011) proposed a five-step model of successful online search: (1) Users face an information need and define a search goal. (2) They select a search engine, choose search terms and send their query off. (3) They scan the resulting search results page and evaluate it based on a set of criteria

such as relevance or credibility. (4) Once they have selected a website for closer inspection, users scan it and extract the required information (again, based on quality criteria such as relevance and credibility). Finally, (5) users need to compare and integrate the information they found on the selected website(s) into a coherent solution for the information problem. As a wealth of empirical research has shown, this ideal online search strategy can however hardly be observed in students across different age groups and educational contexts. For example, Tomaiuolo and Packer (1996) demonstrated that many university students have problems employing appropriate search terms for solving simple retrieval tasks such as "locate the full text of the Magna Charta". Likewise, Brand-Gruwel, Wopereis and Walraven (2009) showed that students often use inadequate criteria to assess the quality of websites, such as the language in which they are written or text length. Thus, there clearly is a need to design instructional interventions that help learners gain online search competence.

Scripting as a way to foster online search competence

A promising way to foster online search competence is having students collaborate (Lazonder, 2005) during their online search and by structuring their collaboration through scripting (e.g., Fischer, Kollar, Mandl & Haake, 2007). Scripts provide learners with direct guidance on how to structure their collaboration by assigning activities and roles to different learners within a social learning setting. One way to differentiate different types of scripts is to distinguish between classroom scripts and small group collaboration scripts (see Kollar et al., 2011). *Classroom scripts* provide coarse-grained activity structures that distribute learning activities over the social levels of the classroom (see Dillenbourg & Jermann, 2007). For example, group level classroom scripts would have all learning activities within a classroom carried out solely by small groups, while a plenary-plus-group-level classroom script might alternate between modeling (as a plenary activity) and dyadic learning activities (as group level activities). Of course, further classroom scripts are conceivable. *Small group collaboration scripts*, in turn, provide more fine-grained guidance with respect to the specific activities that are to be shown within small group collaboration. For example, a small group collaboration script may have one learner of a dyad suggest which link to click on a search results page, while the other learner is prompted to critically reflect upon his/her learning partner's choice based on credibility considerations. As the study by Kollar et al. (2011) demonstrated, both classroom scripts and small group collaboration scripts can be designed in a way that online search competence (as an individual learning outcome) can effectively be facilitated. Further research has produced a wealth of evidence for the potentials of classroom scripts (e.g., Dillenbourg & Hong, 2008; Hmelo-Silver, 2004; Kolodner, 2007) and small group collaboration scripts (e.g., Kollar, Fischer & Slotta, 2007; Rummel & Spada, 2005; Schellens et al., 2007; Tsovaltzi et al., 2010; Wecker & Fischer, 2011) also for the acquisition of skills and competences beyond the online search field.

The present study

As already mentioned, this study provides an in-depth analysis of collaborative online search activities from the study by Kollar et al. (2011). For the purposes of that study, a 4.5 weeks curriculum unit for 9th grade biology classrooms was designed. Over the course of the unit, students had repeated opportunities to use the Internet to develop a well-warranted position on whether Genetic Engineering should be allowed or not. In a 2x2 factorial design, we systematically varied two independent factors: "type of classroom script" (group level classroom script vs. plenary-plus-group-level classroom script) and "small group collaboration script" (with vs. without). In Kollar et al. (2011), the main dependent variable was the students' level of online search competence after completion of the curriculum unit (prior online search competence was controlled for). The results demonstrated that both the small group collaboration script and the plenary-plus-group level classroom script had a positive effect, as long as students were only provided with one of the two. Concerning the combination of the small-group collaboration script and the plenary-plus-group level classroom script, we expected to find a synergistic scaffolding effect, i.e. that receiving modeling of good online search would especially pay off if the subsequent dyadic online search would be structured by appropriate prompting. However, no synergistic scaffolding effect (Tabak, 2004) was found. As these results have already been published, they are not further reiterated in the analyses of this paper. Instead, this paper tries to answer two research questions aiming at a better understanding of the results with respect to the acquisition of online search competence as reported in Kollar et al. (2011):

1. What are the effects of providing learners with a small group collaboration script (vs. unscripted small group collaboration), a plenary-plus-group level classroom script (vs. a group-level classroom script), as well as their interaction on the quality of online search activities exhibited during collaboration?
2. How does the quality of the collaborative online search activities relate to the online search competence individual students demonstrate in a subsequent posttest?

Based on the learning outcome analyses reported in Kollar et al. (2011), we expected an analogous result pattern for the quality of the collaborative online search activities that were shown during collaboration. More specifically, we expected positive effects of both the small group collaboration script and the plenary-plus-group level classroom script, as long as they were provided individually, on the quality of the exhibited

collaborative online search activities. In the combined condition, we expected a significantly lower quality of collaborative online search activities when compared to the condition "plenary-plus-group level classroom script/without small group collaboration script", but a comparable level to students from the condition "group level classroom script/with small group collaboration script". Learners who neither received the small group collaboration script nor the plenary-plus-group level classroom script were expected to show the lowest levels of collaboration online search activities. With respect to the relation between the quality of collaborative online search activities in the process and individual online search competence displayed in the individual posttests, we expected significant and positive correlations in all conditions, i.e. the higher the quality of the collaborative online search activities in the dyads, the higher the individuals' online search competence after collaboration.

Method

Participants and design

Overall, 174 students from eight classes of four high schools from Southern Germany participated in the study. However, only for 151 9th graders data from online search phases as well as the individual posttest were available. Therefore, only these 151 students were included in this study. As described, we established a quasi-experimental 2x2-factorial pre-post test design with the independent factors "type of classroom script" (group level classroom script vs. plenary-plus-group-level classroom script) and "small group collaboration script" (with vs. without). Eight classes were randomly assigned to the four experimental conditions, i.e. each condition was implemented in two classes (see table 1).

Table 1: Design of the empirical study.

		Small-group collaboration script	
		Without	With
Type of classroom script	Group-level	N = 36 students (2 classes)	N = 48 students (2 classes)
	Plenary-plus-group level	N = 22 students (2 classes)	N = 45 students (2 classes)

Instructional setting and independent variables

The experimental design was integrated in a curriculum unit during which students received the task to use the Internet to develop a well-warranted position on the question whether Genetic Engineering should be allowed or not. For this purpose, each single student was equipped with a laptop computer on which a LAN connection was established to allow for Internet browsing. Since the experiment took place in the regular Biology lessons of the participating classes and followed the regular timetable of each class, only two lessons per week in each class took place. Overall, the curriculum unit spanned seven lessons. One additional lesson right before the start of the intervention was used for the administration of pretests, and one lesson right after the end of the intervention was used for posttests. During the seven learning sessions, after a general introduction by the teacher to the topic and to successful online search behavior, three content-specific learning cycles were created. Cycle 1 dealt with economic issues, cycle 2 with ecological issues, and cycle 3 with health-related issues of Genetic Engineering. Each of these cycles consisted of three steps. In step 1, students had the opportunity to browse an online environment that held relevant Biological content knowledge on Genetics and Genetic Engineering. The online environment was created in WISE (Slotta & Linn, 2000), and its content design was based on regular 9th grade Biology textbooks. In step 2, the actual online search phase took place, during which the experimental variation was implemented (see below). During this step, learning mainly took place in dyads. In step 3, classes in all conditions engaged in a plenary discussion that invited the students to exchange and critically discuss the arguments and pieces of evidence they had found or developed during their Internet search.

Independent variables

The two independent factors "type of classroom script" and "small-group collaboration script" were systematically varied during step 2 in each of the three learning cycles, i.e. in the phases in which students were supposed to search the Internet for arguments and evidence that would seem helpful to develop a position in the Genetic Engineering debate. In all four experimental conditions, the Internet browsers of two learning partners each were connected to each other, i.e. whenever one learning partner went to a new website, his/her partner's browser would go there too. This was realized by a browser plug-in called S-COL (Wecker et al., 2010).

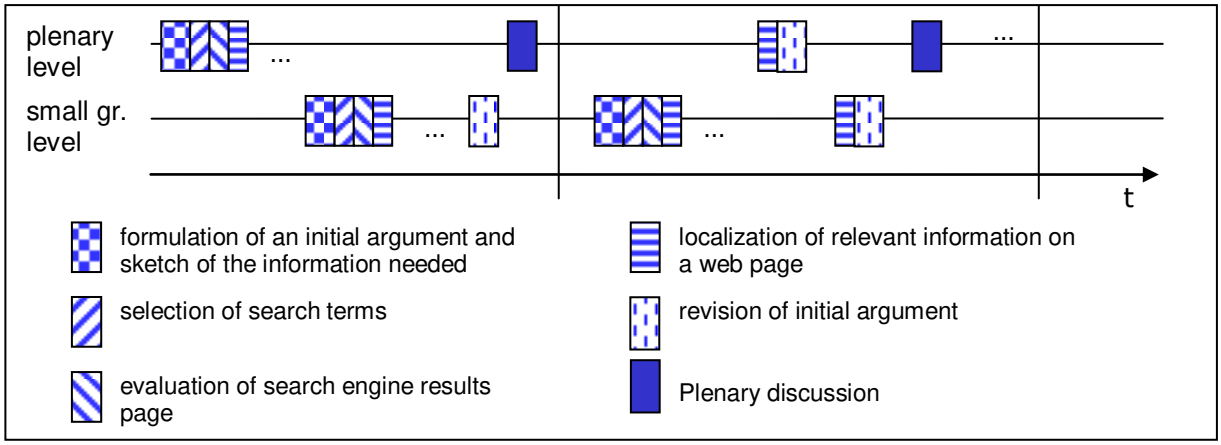

Figure 1. Graphical representation (derived from Dillenbourg & Jermann, 2007) of the plenary-plus-group level classroom script (lines represent the two social levels "plenary" and "small group", boxes represent the different online search activities exhibited on the respective social levels.

In the *plenary-plus-group level classroom script* condition (see figure 1), dyadic online search during step 2 of each cycle was interrupted from time to time by modeling phase (as plenary activities), during which the teacher and a student or two students demonstrated what a successful online search looks like, before student dyads went on with their own online search. The design of the plenary-plus-group level classroom script as well as the content of the modeling phases was based on an adaptation of the five-step online search competence model by Gerjets et al. (2011). Thus, students were instructed to follow a five-step online search strategy: (1) *formulating an initial argument and a sketch of the information needed*, (2) *selecting search terms*, (3) *evaluating the search engine results page (SERP)*, (4) *localizing relevant information* on a web page, and (5) *formulating the final elaborated argument*. For all steps, certain quality criteria were also provided in the modeling phases. For example, during the evaluation of the hit list, students were instructed to discuss the credibility and relevance of the single links. In contrast, in the *group level classroom script* condition, all search activities in step 2 of each content-specific learning cycle were to be conducted in dyads, i.e. dyadic search activities were not interrupted by modeling phases.

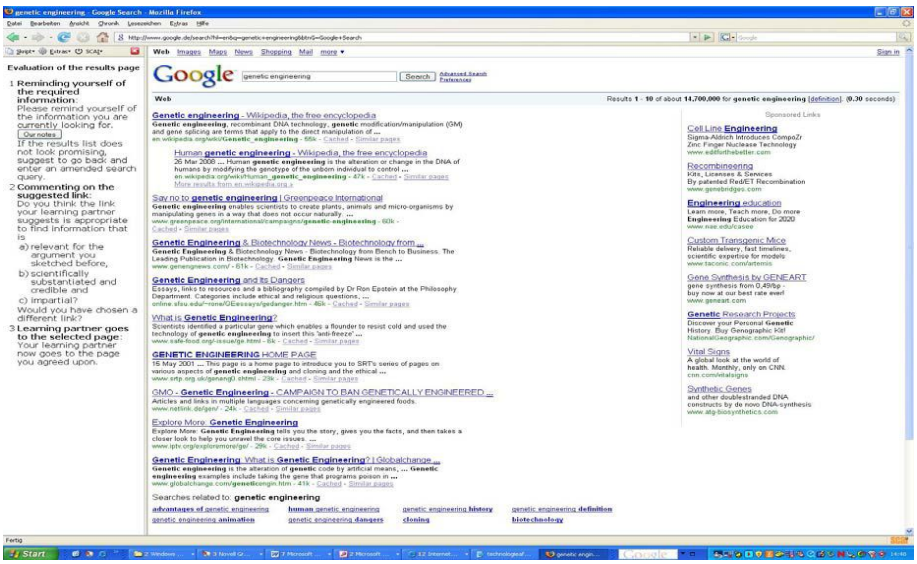

Figure 2. Screenshot of the small group collaboration script (view of the screen of one of the two learners during the step "scan search engine results page"; the right side of the screen displays a regular Google results list; the left side of the screen provides prompts related to this online search step for one of the two learners).

Just like the plenary-plus-group level classroom script, the *small group collaboration script* (see figure 2) was designed on the basis of the adapted five-step online search competence model by Gerjets et al. (2011). For each of the five online search steps, the two learners of each dyad received complementary prompts that told them what to do. Typically, learner A was supposed to suggest what to do next (e.g., suggest a link to click on while the browser displayed a hit list), and learner B was supposed to critically reflect upon the suggestions of

learner A (e.g., by a prompt "Do you think the link your learning partner suggests is appropriate to find information that is (a) relevant for the argument you sketched before, (b) scientifically substantiated and credible and (c) impartial? Would you have chosen a different link?"). With each new search, these two roles were switched among the learning partners. When the small group collaboration script was combined with the plenary-plus-group level classroom script, modelling was alternated with structured dyadic search activities based on the prompts specified in the small group collaboration script. When the small group collaboration script was combined with the group-level classroom script, all search activities were to be conducted in dyads, and all dyads received the prompts that made up the small group collaboration script; however, dyads in this condition did not receive modelling of successful online search. In the condition without small group collaboration script, no prompts were displayed during dyadic online search; however, the Internet browsers of the two learning partners were connected in the way that was described earlier.

Dependent variables

The *quality of the collaborative online search activities* the dyads exhibited during treatment was analyzed based on screen-and-audio-recordings. The first ten minutes of each dyad in each search phase were video-coded based on a coding scheme that was designed on the adapted competence model of successful online search by Gerjets et al. (2011). E.g., we coded whether the students currently performed activities belonging to the step of sketching an argument, or whether they performed activities belonging to the step of evaluating a search engine results page, as well as what quality criteria they applied. The unit of analysis for this analysis were segments of ten seconds, and the predominant activity in these 10 seconds was coded. The mutually exclusive codes were: (1) *formulation of an initial argument and a sketch of the information needed*, (2) *selection of search terms*, (3) *evaluation of the hit list*, (4) *localization of relevant information* on a web page, (5) *formulation of the final elaborated argument*, and (6) *other*. Because all time samples were drawn from the beginning of the online search phases, activities belonging to early steps of the underlying online search model by Gerjets et al. (2011) were more appropriate than later steps. Therefore, a composite indicator of the quality of collaborative search activities was computed that reflects the appropriateness of the activities belonging to each of the five steps of the strategy during the first ten minutes of each search phase. This composite indicator was calculated as the sum of the proportions of time spent on the activities belonging to the more appropriate first two steps "*formulation of an initial argument and sketch of the information needed*" (with fourfold weight) and "*selection of search terms*" (with double weight), minus the sum of the proportions of time spent on the activities belonging to the less appropriate final three steps "*evaluation of the hit list*" (with unit weight), "*localization of relevant information*" (with double weight), and "*written formulation of the final elaborated argument*" (with threefold weight). This indicator was calculated separately for the learners and their learning partners, resulting in two composite indicator variables for strategy performance. A value of higher than 0 would mean that a person displayed more reasonable (step 1 and 2) than unreasonable (steps 3, 4 and 5) activities during the first ten minutes of each search phase, while a value of lower than 0 would mean that s/he displayed more unreasonable (steps 3, 4 and 5) than reasonable (steps 1 and 2) activities. To determine objectivity, a subsample of 11% of the data from this and a further study (Wecker, Kollar & Fischer, 2011) that used the same task and coding scheme (but different experimental variations) was coded by three independent raters, with ICCs for each of the five online search steps of about .90 (*formulation of an initial argument and sketch of the information needed*: *ICC* = .96, *selection of search terms*: *ICC* = .90, *evaluation of the hit list*: *ICC* = .95, *localization of relevant information*: *ICC* = .97, *written formulation of the final elaborated argument*: *ICC* = .88, composite indicator of *strategy performance*: *ICC* = .97).

Online search competence as an individual learning outcome was measured in an individual posttest (see also Kollar et al., 2011) that asked students to describe in as much detail as possible how they would use the Internet to arrive at a reasoned position in a science-related debate different from Genetic Engineering (whether nuclear power plants should be shut down or not). For the pretest, an analogous test on a different science topic was used. Since the results analyzing the effects of the two treatments and their combination on this measure have already been published elsewhere, interested readers are referred to the corresponding paper (Kollar et al., 2011). To understand the analyses of this paper, the result pattern on the acquisition of online search competence however needs to be kept in mind: As reported above, Kollar et al. (2011) found that although both interventions were effective when the other one was not provided, their combination did not yield synergistic scaffolding effects, i.e. it did not affect the effectiveness of the small group collaboration script and even slightly reduced the effectiveness of the plenary-plus-group level classroom script.

Statistical analyses

To determine the effects of the two independent variables on the quality of the collaborative online search activities, an ANCOVA with "type of classroom script" and "small group collaboration script" as fixed factor, classes as further fixed factor nested within the experimental conditions (to account for the hierarchical data structure), the composite indicator for quality of collaborative online search activities as the dependent variable

and prior online search competence as a covariate was conducted. To answer the question on the relation between learning activities and outcomes, bivariate correlations were computed between "quality of collaborative online search activities" and "online search competence (outcome)". For all analyses, the significance level was set to 5%.

Results

With respect to RQ 1 on the effects of the two treatments and their different combinations on the quality of online search activities during collaboration, the descriptive data (see table 2) showed that learners who received the small group collaboration script together with the plenary-plus-group level classroom script exhibited the highest quality levels. The lowest levels were observed when learners did not receive the small group script and followed the group level classroom script. Students from the other two conditions ("with small group collaboration script and group level classroom script" and "without small group collaboration script and plenary-plus-group level classroom script) were in between and reached comparable levels.

Table 2: Means and standard deviations of the (composite indicator of) quality of collaborative online search activities for the four experimental conditions.

	Without small group collaboration script				With small group collaboration script			
	Group level classroom script		Plenary plus group level classroom script		Group level classroom script		Plenary plus group level classroom script	
	M	*SD*	M	*SD*	M	*SD*	M	*SD*
Quality of online search activities	-0.68	*0.33*	-0.49	*0.28*	-0.33	*0.47*	-0.01	*0.50*

An ANCOVA with "type of classroom script" and "small group collaboration script" as fixed factors, classes as a further fixed factor nested within the experimental conditions (to account both for the hierarchical data structure and to control for possible teacher effects), the composite indicator for quality of collaborative online search activities as the dependent variable and prior online search competence as a covariate revealed a significant main effect for the small group collaboration script, $F(1; 142) = 29.23$, $p < .01$, partial $Eta^2 = .17$, with students who had learned with the small group collaboration script outperforming students who did not receive a small group collaboration script. Also, we found a significant main effect for type of classroom script, $F(1; 142) = 14.72$, $p < .001$, partial $Eta^2 = .09$, favoring the conditions with plenary-plus-group level classroom script over learners who had learned with the group level classroom script. There was no significant interaction effect, $F(1; 142) = 0.02$, $p = .88$, partial $Eta^2 < .01$.

With respect to RQ 2 concerning the relation between the quality of collaborative online search activities and the levels of online search competence students displayed in the individual posttest, bivariate correlations were calculated. When all four conditions were taken together, this correlation turned out to be insignificant ($r = .05$, $p = .24$). However, we also calculated separate correlation analyses for the combined condition (small group collaboration script and plenary-plus-group level classroom script) and the remaining three conditions. This revealed an interesting pattern: When both scaffolds were combined, there was a slightly significant negative correlation between the quality of the search strategy during the process and online search competence that students exhibited in the posttest ($r = -.27$; $p = .08$; two-tailed), while for the other three experimental conditions taken together, the correlation was positive and approached statistical significance($r = .18$; $p = .08$; two-tailed).

Discussion

This paper provides an in-depth process analysis of a study presented in Kollar et al. (2011) which showed that both a small group collaboration script and a plenary-plus-group level classroom script that were employed in a curriculum unit on Genetic Engineering in 9th grade Biology classrooms were effective ways of fostering online search competence. Once these two scaffolds were combined, however, neither an addition of effects nor a positive interaction (meaning that both treatments would have amplified each other's effects) appeared. To the contrary, adding the small group collaboration script while a plenary-plus-group level classroom script was implemented tended to reduce the effectiveness of the latter, while the effectiveness of the small group collaboration script compared to unsupported collaboration was not affected by the type of classroom script that was employed. Thus, with respect to the acquisition of individual online search competence, combining a small group collaboration script and a plenary-plus-group level classroom script may have produced what Dillenbourg (2002) termed "overscripting" (for the exact analyses that underlie these results, please see Kollar et al., 2011).

The results of the process analyses presented in the current paper only partially reflect these results, since with respect to the quality of the collaborative online search activities, the two treatments did not work best in isolation, but instead when they were combined, as was indicated by the additive main effects that were found with respect to research question 1. On the one hand, given the incongruence with respect to the results of the learning outcome analyses reported in Kollar et al. (2011), this result is surprising. On the other hand, theoretically it may have been expected, since both the small group collaboration script and the plenary-plus-group level classroom script were specifically designed with the aim to support students during their collaborative online search activities. That the two scripts were effective with respect to this aim, can be regarded as support for previous research that has demonstrated (a) the effectiveness of small group collaboration scripts to facilitate collaborative learning activities (e.g., Schellens et al., 2007) and (b) the effectiveness of instructional classroom approaches that implement specific distributions of learning activities over the different social levels of the classroom, such as Problem-based Learning (Hmelo-Silver, 2004), Learning-by-Design (Kolodner, 2007) or Reciprocal Teaching (Palincsar & Brown, 1984), even though it has to be noted that few empirical studies exist that systematically compared the effects of different distributions of activities over social levels on individual learning outcomes. However, even though we found that the combination of learning with a small group collaboration script and a plenary-plus-group level classroom script was most successful, we still did not find a true synergistic scaffolding effect (Tabak, 2004). Such an effect would mean that the two scaffolds would mutually amplify their effects (i.e. cause a positive interaction effect). It is possible that true synergistic scaffolding was not produced because both scaffolds were redundant, since their design followed the same theoretical assumptions concerning good online search strategies. It might be that once students have seen the teacher or other students model high level online search strategies, they may not have seen the necessity of paying attention to the small group collaboration script prompts anymore. If this is true, this may indeed be labelled an overscripting effect (Dillenbourg, 2002). Further research is necessary to test the validity of this interpretation.

Still, that the additive effects pattern we found with respect to the quality of the collaborative online search activities did not appear on the learning outcome level (using students' performance in the online search competence posttest) requires further consideration, and the correlational analyses we ran with respect to research question 2 are helpful in this respect. As these analyses revealed, when the three conditions that either employed the small group collaboration script or the plenary-plus-group level classroom script alone, or none of the two, were taken together, there was a weak, but (marginally) significant positive correlation between the quality of collaborative search activities and online search competence measured in the posttest. However, in the condition that combined the small group collaboration script and the plenary-plus-group level classroom script, a marginally significant negative correlation of moderate size was observed. In other words, although the combination of these two scaffolds helped students act on a higher level during collaboration, it did not help them to actually acquire the competence; it even tended to hinder their competence acquisition. A tentative explanation for this result could be that students may exhibit a high degree of collaborative online search strategy use without actually internalizing the strategy due to over-reliance on the rich scaffolds with the combination of the two scaffolds. Another interpretation might be that the combination of the two scaffolds has led to an advanced automatization of the online search strategy that was proposed in the two scripts, which may have made it hard for students to have the strategy later available declaratively (since the online search competence test had students describe – and not perform – an ideal online search). Future research is necessary to test these assumptions.

In summary, our results imply that the combination of small group collaboration scripts and plenary-plus-group level classroom scripts seems helpful to help dyads perform higher-level search activities. If the goal is to produce positive effects on individual online search competence, yet, the two scaffolds should rather be given without presenting the other as well.

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