Fostering Online Search Competence and Domain-Specific Knowledge in Inquiry Classrooms: Effects of Continuous and Fading Collaboration Scripts

Christof Wecker, Ingo Kollar, Frank Fischer, University of Munich, Leopoldstr. 13, D-80802 Munich
Helmut Prechtl, Leibniz-Institut für die Pädagogik der Naturwissenschaften und Mathematik, Olshausenstr.62, D-24098 Kiel
christof.wecker@psy.lmu.de, ingo.kollar@psy.lmu.de, frank.fischer@psy.lmu.de, prechtl@ipn.uni-kiel.de

Abstract: Collaborative inquiry learning can be regarded as a fruitful approach to foster students' scientific literacy for participation in societal debates involving scientific issues. In a four-week field study in biology with 131 ninth-grade students from six classrooms distributed over three experimental conditions, we investigated the effects of a continuous and a fading collaboration script for collaborative online search compared to unsupported collaboration on students' online search competence and domain-specific knowledge. Findings indicate a superiority of a continuous collaboration script compared to unsupported collaboration with respect to both students' online search competence and domain-specific knowledge, whereas the fading collaboration script had a significant positive effect compared to unsupported collaboration only with respect to students' online search competence. These findings extend our knowledge from laboratory research on effects of collaboration scripts on domain-general competences and domain-specific knowledge.

Scientific literacy as a goal of science education in schools

A main purpose of science education is not so much to educate future scientists or engineers, but rather to prepare all students as responsible citizens for participation in societal debates that involve scientific issues. Current examples of such issues are the prospects and risks of nuclear power, the genetic engineering of crops and other plants for purposes of food production, or preimplantation genetic diagnosis.

For the development of reasoned positions about these questions, scientific literacy is an important prerequisite (Laugksch, 2000), which involves both fundamental knowledge about important scientific principles and the ability to gather and evaluate more specific and recent information that goes beyond what can ever be learned in school. Current information and communication technology has made such information widely accessible. Accordingly, we regard domain-specific scientific knowledge, i. e. knowledge of basic terms, knowledge of important facts and understanding of fundamental explanatory principles, as well as online search competence, i. e. the ability to localize and evaluate relevant scientific information on the internet, as two crucial components of scientific literacy that all students should develop in order to be able to participate in tomorrow's science-related societal debates. To develop instruments for measuring and support for fostering online search competence, we conducted a cognitive task analysis of internet search tasks which ask learners to use the internet to gather evidence they could use to formulate arguments in societal, science-related debates (see Kollar, Wecker & Fischer, 2009). Following that, we validated the resulting model of competence by asking an online search expert, a content expert and a search novice to think aloud during such tasks. Most importantly, the think aloud study showed that both experts, after having built an initial argument sketch, established a scheme for what counted as evidence to support their position and let this evidence scheme guide their internet search behaviour. The novice, in contrast, browsed through the internet in a rather mindless fashion, not much really taking care of relevance, credibility or scientific quality of web site content, finally arriving at less sound arguments that were supported by less reliable information found on the Web.

Collaborative inquiry learning as an approach to foster scientific literacy

Scientific literacy and its sub-components domain-specific knowledge and online search competence can be fostered in inquiry learning contexts (e.g., de Jong, 2006), which are implemented with the aid of digital media and internet technologies that afford collaboration between students (see Slotta & Linn, 2000). In web-based inquiry learning, students use computer and internet technologies (usually in groups) to work on authentic scientific phenomena or problems in a way similar to scientists. It can be argued that by engaging in such activities, scientific literacy may be developed, since they typically involve elaborating upon domain-specific scientific knowledge and using digital media to gather evidence, which may foster online search competence.

As empirical evidence shows, however, for inquiry learning to be productive, it needs to be structured and scaffolded appropriately (de Jong & van Joolingen, 1998). Therefore, web-based environments include a variety of scaffolds designed to facilitate students' inquiry processes. For example, the Web-based Inquiry Science Environment (WISE; Slotta & Linn, 2000) includes hint questions designed to trigger elaborations, mapping tools to visualize the relations between multiple variables, or background information on the given

science problem. As an analysis of WISE and several other web-based inquiry learning environments shows, however, most environments lack support that directly aims at scaffolding the collaboration process between the learning partners. Against the background of empirical research on collaborative learning, which shows that collaboration rarely reaches high quality when it happens spontaneously (Gillies, 2003), the use of scaffolds directed at an improvement of collaboration seems to be warranted.

Collaboration scripts to support collaborative inquiry learning

One promising way of providing such support is to develop collaboration scripts (Kollar, Fischer & Hesse, 2006; Dillenbourg & Jerman, 2007) and integrate them into web-based inquiry learning environments. Collaboration scripts are socio-cognitive scaffolds that specify activities, sequence them and distribute them among different roles taken over by members of a small group of learners (Kollar et al., 2006).

Despite some research about the effects of collaboration scripts on learning processes (e. g. De Wever, Van Keer, Schellens & Valcke, 2009), their effects on learning outcomes have been investigated mainly in laboratory experiments. Several lab studies about computer-supported collaborative learning during online discussions in a problem-based learning context demonstrated beneficial effects of different kinds of collaboration scripts on students' domain-general competencies (Weinberger, Ertl, Fischer & Mandl, 2005; Stegmann, Weinberger & Fischer, 2007). However, only for some types of computer-supported collaboration scripts, e.g., a peer-review script, beneficial effects with respect to the domain-specific knowledge could be found (Weinberger et al., 2005; Diziol, Rummel, Spada & Mclaren, 2007). In the context of web-based inquiry learning, a collaboration script aimed at helping students to form well-grounded arguments, counterarguments and integrations was developed and integrated at specific points of as WISE curriculum unit (Kollar, Fischer & Slotta, 2007). In line with previous research, this script helped students develop higher levels of the domain-general competence of argumentation, but did not help them reach higher levels of domain-specific knowledge when compared with less structured collaboration. Moreover, it appeared that during the learning process the collaboration script only raised argumentation quality as long as it was present. As soon as the script was "switched off", learners relapsed into their previous argumentation style. In other words, internalization of the argumentation strategy was low, which may be explained by a rather short learning time of 120 minutes. The question whether computer-supported collaboration scripts produce more robust effects when longer learning phases are studied is yet unanswered.

The fading of collaboration scripts

The laboratory research mentioned clearly indicates a need for finding ways to support the internalization of strategies targeted by collaboration scripts. One such approach is the fading of support, which is considered as part and parcel of scaffolding (Pea, 2004; Wood, Bruner & Ross, 1976). Up to now research on the effects of the fading is sparse, and the results are mixed. In one of two experiments, evidence for beneficial effects of fading was found, whereas in the other one performance decreased in the process of fading (Leutner, 2000). In a second study a marginally significant positive effect of fading was demonstrated with respect to only one of several aspects of knowledge about the principles of scientific explanations (McNeill, Lizotte, Krajicik & Marx, 2006). No effect of fading on the quality of explanations in the posttest was found in a further study, while during the learning phase the quality of explanations decreased in the process of fading (Lee & Songer, 2004).

An empirical study about the effects of the *fading of scripts* showed that fading alone had no positive effect on learning (Wecker & Fischer, 2007). If it was combined with "distributed monitoring" (cf. King, 1998), i. e. when the learning partner was asked to monitor whether his or her peer complied with the strategy induced by the script, a significant positive effect on students' strategy knowledge in comparison to a continuous script was found. However, this study was also conducted as a lab experiment with a rather short learning time.

Research questions

The summary of the current state of research provided above warrants further consideration whether the effects of small-group collaboration scripts as well as their fading show up also in real science classrooms. Furthermore, it needs to be investigated whether collaboration scripts as well as their fading can foster also domain-specific knowledge, if more extended learning phases are implemented. The opportunity to shift the focus from the application of a domain-general strategy targeted by the collaboration script to the elaboration of domain-specific content to be learned during longer learning phases would warrant such expectations.

Accordingly, our research questions were the following:

(1) What are the effects of a small-group collaboration script as well as its fading on students' domain-specific knowledge?

We expected that in classroom-based inquiry learning over a comparably extended period of time domain-specific knowledge is fostered if collaboration is supported by a collaboration script compared to collaboration without a collaboration script. According to the line of reasoning just presented, a beneficial effect of a fading collaboration script on students' domain-specific knowledge could also be expected.

(2) What are the effects of a small-group collaboration script as well as its fading on students' online search competence?

In line with the bulk of previous findings about the effects of small-group collaboration scripts from the laboratory we assumed a positive effect of a collaboration script compared to collaboration without a collaboration script on students' online search competence. We further hypothesized that a fading collaboration script would have a beneficial effect on students' online search competence compared to both collaboration without a collaboration script and collaboration supported by a continuous collaboration script.

Method

Participants and design
The participants were 131 students from six ninth-grade classes from three urban high schools. They were on average 14.7 years old ($SD = 0.75$); 53 of them were girls, 78 were boys. The decision to participate in the project rested with the biology teachers of the classes. However, data from the individual students were only collected if their parents had agreed individually.

Three experimental conditions differing in the amount of instructional support for collaborative online search were compared in a one-factorial quasi-experimental design with the classes as the units of random assignment. The first condition involved no collaboration script, the second a continuous collaboration script, and the third a fading collaboration script (see table 1).

Table 1: Design of the study.

No collaboration script	Continuous collaboration script	Fading collaboration script
N = 43 students from 2 classes	N = 34 students from 2 classes	N = 54 students from 2 classes

Curriculum unit and instructional setting
The study was conducted in the context of an inquiry-based curriculum unit that spanned seven regular biology lessons, which were preceded and followed by one test session each (see table 2). During the unit, the students were supposed to arrive at a decision about whether they supported or rejected "green" Genetic Engineering, i. e. the genetic modification of plants for the purpose of food production. All lessons in this curriculum unit were led by the regular biology teachers of the participating classes.

Table 2: Procedure of the study and phases of the instructional unit.

Cycle	Lesson	Activity	Duration
	0	Pretest	45 min
	1	Introduction to background domain knowledge	45 min
1	2	Introduction to *economic aspects* of "green" genetic engineering	5 min
		Introduction to the online search strategy	5 min
		Studying of background information relevant to *economic aspects* of "green" genetic engineering	35 min
	3	Online search on *economic aspects* of "green" genetic engineering	45 min
	4	Discussion about *economic aspects* of "green" genetic engineering	15 min
2		Introduction to *ecological aspects* of "green" genetic engineering	5 min
		Studying of background information relevant to *ecological aspects* of "green" genetic engineering	20 min
	5	Online search on *ecological aspects* of "green" genetic engineering	30 min
		Discussion about *ecological aspects* of "green" genetic engineering	15 min
3	6	Introduction to *health aspects* of "green" genetic engineering	5 min
		Studying of background information relevant to *health aspects* of "green" genetic engineering	40 min
	7	Online search on *health aspects* of "green" genetic engineering	30 min
		Discussion about *health aspects* of "green" genetic engineering	15 min
	8	Posttest	45 min

The unit started with a short introduction to relevant background domain knowledge from Genetics. To keep the information about the strategy of online search to be acquired constant, the students in all three conditions also received the same introduction to this strategy.

Lessons two through seven consisted of three consecutive learning cycles about three different topical aspects of the discussion about "green" Genetic engineering: one on economic, one on ecological, and one on health aspects. Each cycle consisted of three consecutive steps. First, the students were asked to collaboratively browse through an online library in dyads in order to gather background information about Genetics and Genetic Engineering relevant to the current topical aspect of the discussion. In the second step, student dyads conducted collaborative online searches to support, discard or modify their initial argument concerning the current topical aspect of the discussion according to the strategy they were introduced to before. In these phases of collaborative online search, which took place in lessons three, five and seven, the independent variable was manipulated (see below). In the third step, the teacher led a plenary discussion in which students exchanged their elaborated arguments based on the findings from their collaborative online searches.

Students collaborated face-to-face sitting next to each other. The technical equipment both to access the online library and conduct the online searches comprised a wireless network and one laptop computer with a mouse per student. The students kept these computers throughout the time of each lesson and received the same computer each time, which served two purposes: On the one hand, students were enabled to create documents and to revisit or edit them in later sessions; on the other hand, this procedure facilitated data collection in that it was easy to track which student had worked on which computer.

The online library was implemented as a module in the Web-Based Inquiry Environment (WISE). It comprised three pages with assignments for the three topical aspects of the discussion (economic, ecological and health aspects) and six sections about topics from Genetics and Genetic Engineering designed on the basis of regular ninth-grade Biology school books.

During the collaborative online search phases, the browsers of the collaborating students in each dyad were connected via a software tool named S-COL (Wecker et al., 2009). This allowed for collaborative internet browsing, i.e., during their online searches, both learning partners from each dyad always saw the same web pages, no matter who of them clicked on a link or performed a web search.

Independent variables

The amount of instructional support for collaborative online search was varied among a condition without collaboration script, a condition with a continuous collaboration script, and a condition with a fading collaboration script.

No collaboration script

In this condition, the browsers of the two students in each dyad were connected as described. These students received no support beyond the teacher's introduction to the strategy of online search at the beginning of the curriculum unit. This information was equivalent to the information presented in the collaboration scripts in the other two conditions.
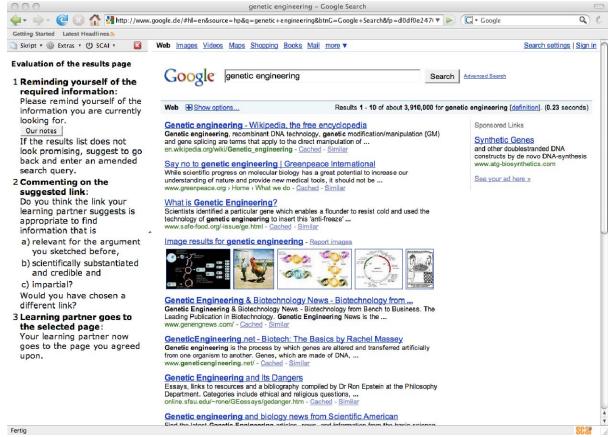
Continuous collaboration script

In addition to connecting the computers of the two partners of a dyad, the S-COL software tool described above was used in the two experimental conditions to display particular prompts on the basis of the type of website the students were accessing (Google start page, Google hit list, any other web site).

In each dyad there were two roles (A and B) that switched after returning to Google (which they were required to use for their searches) from any other web page encountered during the search activities. The collaboration script was implemented as complementary text prompts in the scaffolding areas of S-COL in the browsers of both group members (see left part of the screen in figure 1). The script contained prompts for helping students formulate an initial argument and sketch the information needed, select search terms, evaluate the hit list, localize relevant information on a web page, and write the final elaborated argument. For example, during the selection of search terms, learner A was prompted to suggest a set of terms and discuss them with B, while B had the task to first recall the information they had decided to look for, and comment on A's suggestions for the search terms with respect to their likelihood of yielding suitable as well as inappropriate hits.

Fading collaboration script

In the condition with the fading collaboration script the same prompts as in the condition with the continuous collaboration script were used to support collaborative online search, but they were gradually removed (faded out) over the whole extension of the curriculum unit depending on the number of online searches the students had performed. After a series of four external web sites accessed, the prompts described before became more unspecific: Initially, the scaffolding area of S-COL contained both the names of the individual steps as well as explanatory text. In the second fading phase, only the names of the steps were displayed. In the final phase, only headings for the actual activity were displayed.

Figure 1: Part of the continuous collaboration script presented along with a Google hit list (collaboration script prompts for one of the two learners displayed in the area on the left; Google hit list displayed in the area on the right)

Procedure

The procedure of the study was as follows (see table 2): The biology lesson immediately before the start of the instructional unit was used for a 45-minute pre-test for online search competence, domain knowledge and control variables. The following phase was constituted by the seven lessons described above, distributed over a period of three and a half weeks. This phase included the manipulation of the independent variable in lessons three, five and seven. In the biology lesson immediately following the instructional unit, a 45-minute post-test was conducted, which included online search competence, domain knowledge and further control variables.

Dependent variables

Domain-specific knowledge

Domain-specific knowledge was measured in the post-test by a test that consisted of 18 items about Genetics and Genetic Engineering. One third of them covered knowledge about concepts, another third factual knowledge and another third understanding of explanatory relations. The items from these three subscales were evenly distributed over different types of answering format (six multiple choice, twelve open). A six-item version of the test with precisely the same structure was used to measure domain-specific knowledge in the pre-test. The answers to the items with an open answering format were analyzed with respect the occurrence of propositions taken from an extremely elaborate expert solution that contained any correct proposition that could conceivably be part of a student's solution For each of these propositions it was coded whether the student's answer contained it or not. Three coders coded 10 % of the material independently of each other to assess the objectivity of the analysis. The average percentage of agreement with respect to the different coding variables was 98 %; Cohen's kappa amounted to $\kappa = .94$ on average. For each item from the test the proportion of the propositions that were included in the student's answer was determined (values between 0 and 1). These proportions as well as the scores from the multiple-choice items were summed up across the different items, yielding an overall scale for *domain-specific knowledge* ranging from 0 to 18 with a reliability of Cronbach's α = 59). Three subscales ranging from 0 to 6 for *knowledge about concepts*, *factual knowledge* and *understanding* are also used in the statistical analyses. Due to the highly elaborated nature of the underlying expert solution, even low scores indicate substantial knowledge.

<u>Online search competence</u>

Online search competence was measured by a task in which the students were asked to describe in as much detail as possible how they would use the internet to form a position about a specific sample issue without actually doing so. In the pre-test, the sample issue the students could use for their description was whether mobile phone transmitters should be forbidden in the neighbourhood of day nurseries. In the post-test, the corresponding issue was whether nuclear power plants should be abandoned. The answers were pre-structured by means of a two-column table of up to eight rows. The left-hand column was to be used for the description of the single steps involved in the search, whereas the right-hand column was to be used for the description of the evaluative criteria to be applied in combination with the specific steps. Both pre- and post-test were coded for the occurrence of each individual element of a general expert solution that contained all the steps as well as all the evaluative criteria from the strategy explained to the students in all three conditions in the introduction and suggested by the collaboration script in the conditions with continuous or fading collaboration scripts. The average percentage of agreement with respect to the different coding items was 96 %; Cohen's kappa amounted to $\kappa = .65$ on average. An overall scale for *online search competence* was formed by counting the positively coded variables, with a reliability of Cronbach's $\alpha = .57$. Separate scales for *knowledge about single steps* and *knowledge about evaluation criteria* were also formed (with some coding items excluded from both subscales). As in the case of domain-specific knowledge, even low scores indicate considerable amounts of competence due to the complexity of the underlying expert solution.

Statistical analysis

The significance level was set to 5 % for all analyses. All analyses of variance or covariance were conducted with the manipulated instructional support as one independent factor and the classrooms as a further independent factor nested within the experimental conditions. The covariates used were significantly correlated with the dependent variables.

Results

Research question 1: Effects of a small-group collaboration script and its fading on students' domain-specific knowledge

With respect to the effects of the two collaboration script versions on students' domain-specific knowledge, analyses of covariance were conducted with the overall domain-specific knowledge scale and the subscales for knowledge about concepts, factual knowledge and understanding as dependent variables, classes nested within the three kinds of instructional support as well as the kind of instructional support as independent variables, and the overall domain-specific prior knowledge as a covariate. As can be seen from table 3, with respect to all four dependent measures students from the condition with the continuous collaboration script outperformed both students from the condition without a collaboration script and from the condition with the fading collaboration script. A significant main effect of the kind of instructional support was detected for the overall scale of domain-specific knowledge ($F(2; 124) = 7.66$; $p < .01$; partial $\eta^2 = .11$), which amounts to a medium to large effect. A planned comparison between the condition without a collaboration script and the condition with a continuous collaboration script was significant, $F(1; 72) = 5.49$; $p = .02$; partial $\eta^2 = .07$. The planned contrast between the condition without a collaboration script and the fading collaboration script did not reach significance in the expected direction, $F(1; 92) = 2.64$; $p = .11$; partial $\eta^2 = .03$.

Further analyses revealed that the detected effect of the kinds of instructional support is due to parallel patterns of significant effects of approximately medium size in all three subscales of domain-specific knowledge: knowledge about concepts, $F(2; 124) = 4.54$; $p = .01$; partial $\eta^2 = .07$, factual knowledge, $F(2; 124) = 3.27$; $p = .04$; partial $\eta^2 = .05$, and understanding, $F(2; 124) = 4.98$; $p = .01$; partial $\eta^2 = .07$.

With respect to one of the scales of domain-specific knowledge, knowledge about concepts, also substantial between-classroom variance was found ($F(3; 124) = 4.27$; $p = .01$; partial $\eta^2 = .09$) which may be caused by factors beyond our experimental conditions, e.g. the teacher's behaviour or the class climate.

Research question 2: Effects of a small-group collaboration script and its fading on students' online search competence

With respect to students' online search competence, analyses of covariance were conducted with the overall online search competence scale and the subscales for knowledge about single steps and knowledge about evaluation criteria as dependent variables, classes nested within the three kinds of instructional support as well as the kind of instructional support as independent variables, and the overall prior online search competence as a covariate. Table 4 shows that descriptively students in the two conditions with the continuous and the fading collaboration script outperformed students in the condition without a collaboration script on the overall online

search competence scale as well as the two subscales knowledge about single steps and knowledge about evaluation criteria. The main effect of the kinds of instructional support with respect to the overall scale was significant and of medium size, $F(2; 124) = 5.16$; $p = .01$; partial $\eta^2 = .08$. Both the planned comparison between the continuous collaboration script and no collaboration script, $F(1; 72) = 9.97$; $p < .01$; partial $\eta^2 = .12$, and the planned comparison between the fading collaboration script and no collaboration script, $F(1; 92) = 7.17$; $p = .01$; partial $\eta^2 = .07$, were significant. However, the final planned comparison between the fading collaboration script and the continuous collaboration script was not significant, $F(1; 83) < 1$; $p = .81$; partial $\eta^2 < .01$.

Table 3: Means and standard deviations of the dependent variables in the three experimental conditions.

		No collaboration script		Continuous collaboration script		Fading collaboration script	
		M	*SD*	*M*	*SD*	*M*	*SD*
Domain-specific knowledge	**Pretest**	**0.67**	**0.72**	**0.68**	**0.68**	**0.78**	**0.69**
	Posttest	**3.58**	**1.53**	**4.54**	**1.81**	**3.14**	**1.88**
Knowledge about concepts	**Pretest**	**0.14**	**0.23**	**0.07**	**0.18**	**0.19**	**0.28**
	Posttest	**1.49**	**0.77**	**1.95**	**0.93**	**1.40**	**1.00**
Factual knowledge	**Pretest**	**0.12**	**0.32**	**0.09**	**0.29**	**0.11**	**0.32**
	Posttest	**0.90**	**0.79**	**1.26**	**0.68**	**0.90**	**0.75**
Understanding	**Pretest**	**0.42**	**0.49**	**0.52**	**0.54**	**0.47**	**0.54**
	Posttest	**1.19**	**0.84**	**1.33**	**0.74**	**0.84**	**0.76**
Online search competence	**Pretest**	**3.46**	**2.10**	**3.03**	**2.43**	**3.59**	**2.33**
	Posttest	**2.65**	**2.27**	**3.68**	**2.41**	**3.85**	**2.65**
Knowledge about single steps	**Pretest**	**2.35**	**1.48**	**2.06**	**1.76**	**2.39**	**1.77**
	Posttest	**1.74**	**1.48**	**2.56**	**1.66**	**2.61**	**1.94**
Knowledge about evaluation criteria	**Pretest**	**1.00**	**0.82**	**0.85**	**0.86**	**0.96**	**0.82**
	Posttest	**0.86**	**1.08**	**1.03**	**1.11**	**1.06**	**1.04**

Further analyses demonstrated that the significant effect with respect to the overall scale is due only to an effect of the kinds of instructional support on knowledge about single steps, $F(2; 124) = 5.49$; $p = .01$; partial $\eta^2 = .08$. There is no significant corresponding effect with respect to knowledge about evaluation criteria, $F(2; 124) < 1$; $p = .41$; partial $\eta^2 = .01$.

With respect to all scales of online search competence, i. e. the overall scale of online search competence ($F(3; 124) = 4.19$; $p = .01$; partial $\eta^2 = .09$) as well as the subscales of knowledge about single steps ($F(3; 124) = 2.96$; $p = .04$; partial $\eta^2 = .07$) and knowledge about evaluation criteria ($F(3; 124) = 3.42$; $p = .02$; partial $\eta^2 = .08$), however, there was also substantial between-classroom variance corresponding to medium effect sizes.

Discussion

The results indicate that the collaboration script approach (Kollar et al., 2006) could successfully be transferred to structure web-based collaborative inquiry learning in real secondary school classrooms. Indeed, the collaboration script was powerful enough to lead learners to higher levels of both domain-specific knowledge and online search competence than unsupported collaboration. Probably, the script helped learners to engage in higher-level internet search processes and also to show a deeper elaboration of the domain-specific information provided in the online project library. Possibly, the high-level evaluation of information prompted by the collaboration script raised the learners' awareness of the need to produce arguments of a high domain-specific quality so that they could stand during the plenary discussions, which may have contributed to a deeper elaboration of domain-specific information that could be found online.

With respect to the effectiveness of the fading of the collaboration script, however, results are mixed: It did not add to the positive effects of the continuous script on students' online search competence, and did not even lead to better results with respect to domain-specific knowledge than the unstructured control group. Obviously, fading alone does not seem to be enough to foster the internalization of a search strategy but very likely needs to be combined with further instructional support (cf. Wecker & Fischer, 2007). For example, it might be helpful to have the teacher from time to time model crucial steps of the search process in front of the whole class (see Rosenshine & Meister, 1994), so that the students are reminded of the strategy the script presented before it is faded (which we are currently investigating in a follow-up study).

Finally, it deserves mention that on most dependent measures we found considerable variance between classes. Thus, further aspects of the learning situation (such as teaching style or class climate) definitely have an

impact on the success or failure of collaboration scripts in web-based collaborative inquiry learning. Future research should clarify what classroom variables influence students' learning outcomes.

References

de Jong, T. (2006). Technological advances in inquiry learning. *Science, 312*, 532-533

de Jong, T. & van Joolingen, W. R. (1998). Scientific discovery learning with computer simulations of conceptual domains. *Review of Educational Research, 68 (2),* 179-201.

De Wever, B., Van Keer, H., Schellens, T. & Valcke, M. (2009). Structuring asynchronous discussion groups: the impact of role assignment and self-assessment on students' levels of knowledge construction through social negotiation. *Journal of Computer Assisted Learning, 25*, 177-188.

Dillenbourg, P. & Jermann, P. (2007). Designing integrative scripts. In F. Fischer, H. Mandl, J. M. Haake & I. Kollar (Eds.), *Scripting computer supported communication of knowledge: Cognitive, computational and educational perspectives* (pp. 275-301). New York: Springer.

Diziol, D., Rummel, N., Spada, H. & McLaren, B. (2007). Promoting Learning in Mathematics: Script Support for Collaborative Problem Solving with the Cognitive Tutor Algebra. In C. Chinn, G. Erkens & S. Puntambekar (Eds.), *Mice, Minds, and Society: CSCL 2007* (pp. 39-41). ISLS.

Gillies, R. (2003). The behaviours, interactions, and perceptions of junior high school students during small-group learning. *Journal of Educational Psychology, 95*, 137-147.

King, A. (1998). Transactive peer tutoring: Distributing cognition and metacognition. *Educational Psychology Review, 10*, 57-74.

Kollar, I., Fischer, F., & Hesse, F. W. (2006). Computer-supported collaboration scripts – a conceptual analysis. *Educational Psychology Review, 18*(2), 159-185.

Kollar, I., Fischer, F. & Slotta, J.D. (2007). Internal and external scripts in computer-supported collaborative inquiry learning. *Learning and Instruction, 17*, 708-721.

Kollar, I., Wecker, C. & Fischer, F. (2009). *Supporting high-school students' scientific literacy through structured inquiry - a use-inspired basic research program.* Paper presented at the 13th Biennial Conference of the European Association of Learning and Instruction, August 25 – 29, Amsterdam.

Laugksch, R. C. (2000). Scientific Literacy: A conceptual overview. *Science Education, 84*, 71-94.

Lee, H. S. & Songer, N. B. (2004). Expanding an understanding of scaffolding theory using an inquiry-fostering science program. Unpublished manuscript.

Leutner, D. (2000). Double-fading support – a training approach to complex software systems. *Journal of Computer Assisted Learning, 16*, 347-357.

McNeill, K. L., Lizotte, D. J., Krajcik, J. & Marx, R. W. (2006). Supporting students' construction of scientific explanations by fading scaffolds in instructional materials. *Journal of the Learning Sciences, 15(2)*, 153-191.

Pea, R. (2004). The social and technological dimensions of scaffolding and related theoretical concepts for learning, education, and human activity. *Journal of the Learning Sciences, 13(3)*, 423-451.

Rosenshine, B. & Meister, C. (1994). Reciprocal teaching: A review of the research. *Review of Educational Research, 64*(4), 479-530.

Slotta, J. D. & Linn, M. C. (2000). How do students make sense of internet resources in the science classroom? In M. J. Jacobson & R. Kozma (Eds.), *Learning the sciences of the 21st century.* Mahwah, NJ: Erlbaum.

Stegmann, K., Weinberger, A. & Fischer, F. (2007). Facilitating argumentative knowledge construction with computer-supported collaboration scripts. *International Journal of Computer-Supported Collaborative Learning, 2(4)*, 421-447.

Wecker, C. & Fischer, F. (2007). Fading scripts in computer-supported collaborative learning: The role of distributed monitoring. In C. Chinn, G. Erkens & S. Puntambekar (Eds.), *Mice, Minds, and Society: CSCL 2007* (pp. 763-771). ISLS.

Wecker, C., Stegmann, K., Bernstein, F., Huber, M. J., Kalus, G., Rathmeyer, S., Kollar, I. & Fischer, F. (2009). Sustainable script and scaffold development for collaboration on varying web content: The S-COL technological approach. In C. O'Malley, D. Suthers, P. Reimann & A. Dimitracopoulou (Eds.), *Computer supported collaborative learning practices: CSCL2009 Conference Proceedings* (pp. 512-516). ISLS.

Weinberger, A., Ertl, B., Fischer, F. & Mandl, H. (2005). Epistemic and social scripts in computer-supported collaborative learning. *Instructional Science, 33(1)*, 1-30.

Wood, D. J., Bruner, J. S. & Ross, G. (1976). The role of tutoring in problem-solving. *Journal of Child Psychology and Psychiatry, 17*, 89-100.

Acknowledgments