COMPUTER-SUPPORTED COLLABORATIVE INQUIRY LEARNING IN DIFFERENTLY STRUCTURED CLASSROOM SCRIPTS: EFFECTS ON HELP-SEEKING PROCESSES AND LEARNING OUTCOMES

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Embedding Computer-Supported Collaborative Inquiry Learning in Differently Structured Classroom Scripts: Effects on Help-Seeking Processes and Learning Outcomes

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Abstract

This study examined the influence of classroom-script structure (high vs. low) during computer-supported collaborative inquiry learning on help-seeking processes and learning gains in 54 student pairs in secondary science education. Screen- and audio-capturing videos were analysed according to a model of the help-seeking process. Results show that the structure of the classroom script substantially affects patterns of student help seeking and learning gain in the classroom. Overall, students in the high-structured classroom-script condition sought less help but learnt more than those in the low-structured classroom-script condition.

Keywords: Classroom script; Computer-supported collaborative inquiry learning; Help-seeking process

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1. Introduction

Applying collaborative inquiry learning to science education entails the joint involvement of learners in scientific activities such as searching for literature, formulating hypotheses, and gathering and interpreting scientific data. These tasks are considered to be highly challenging and even overwhelming if they are not adequately supported, for example, by scaffolding, small group scripting and expert support (e.g., Linn, 2006; Kollar, Fischer, & Slotta, 2007). A central question pertains to whether students appropriately use the help that is available in a classroom (e.g., teacher, peer learner, computer). So far, we know that students often refrain from seeking help from their peer learners or their teacher when conducting typical inquiry tasks, such as formulating hypotheses or interpreting data (van Joolingen, de Jong, Lazonder, Savelsbergh, & Manlove, 2005). Not asking for help when it is needed is not a problem that is exclusive to collaborative inquiry-learning classrooms; help-seeking research has indicated that this phenomenon is generally widespread across a variety of educational settings (Aleven, Stahl, Schworm, Fischer, & Wallace, 2003; Newman, 2000; Ryan, Pintrich, & Midgley, 2001). Research findings in other areas of help seeking indicate substantial inter-learner variability with respect to help-seeking behaviour and further suggest that better help seekers also learn more (e.g., Ryan & Shim, 2006; Webb, Ing, Kersting, & Nemer, 2006). The literature also indicates that help-seeking processes can be affected by patterns of classroom interaction and facilitated by instruction (Aleven et al., 2003; Karabenick & Newman, 2009). To date however, there has been little research on the question concerning how different patterns of classroom interaction (also termed classroom scripts) in collaborative inquiry learning support or hinder help-seeking processes (see also Nelson-Le Gall, 1981). Methodologically, research in the area of help seeking has so far primarily been questionnaire based, and there is a clear need for empirical studies including measures of help-seeking behaviour and consequential learning outcomes in real learning contexts. The present study examined the effects of different classroom scripts in collaborative inquiry learning on help-seeking processes and learning outcomes in the science education classroom.

1.1. Help-seeking process

Research on inquiry learning has repeatedly shown that the inquiry process can be demanding and challenging for students and may thus hinder further learning (e.g., van Joolingen et al., 2005). One reason for this may be that learners are unable to deal with these demanding processes in a way which involves seeking help from peer learners and teacher. We suggest conceptualising processes associated with such problems as *help-seeking processes* and refer to the model developed by Nelson-Le Gall (1981) in which different stages of help seeking are distinguished: (a) becoming aware of a problem, (b) making a decision to seek help, (c) identifying an appropriate source of help, such as peers, teacher, or technology, (d) implementing strategies for getting help, and (e) evaluating the help received.

Learners who are able to self-regulate their learning processes are also able to identify their problems and indicate whether and what kind of help they need to successfully solve a problem (see Newman, 1998; Puustinen, 1998; Webb & Palincsar, 1996). Help-seeking behaviour which enhances help seekers' independent problem solving, that is instrumental help (Nelson-Le Gall, 1981), and which includes asking for explanations and hints, is seen as particularly beneficial for learning. However, in order to increase the probability of receiving meaningful help, learners must be able to adequately formulate a request so that help givers can respond to the help required in a specific manner and are willing to provide assistance (Webb & Mastergeorge, 2003; Webb et al., 2006). Help seekers should subsequently utilise the received help to solve a problem or complete a task (Webb et al., 2006). It is therefore important to also investigate the type of help received and the usage of the help received.

Help seeking is a process which is highly socially interactive, especially in the classroom context (see Karabenick & Newman, 2009; Ryan & Shin, this issue). In seeking help, it is necessary for a learner to approach others. For many learners, this step might be crucial and to some extent explain why help seeking is often avoided (e.g., Ryan et al., 2001; Butler, 2006; Karabenick & Newman, 2009). It would therefore seem important to investigate how classroom interaction affects students' help-seeking behaviour in order to support interaction in a way that enhances the kind of help-seeking behaviour which in turn fosters learning.

1.2. Classroom scripts for inquiry learning

Previous research on help seeking has shown that teacher behaviour and the resulting classroom discourse might substantially encourage or hinder student help seeking (Butler, 2006; Karabenick & Newman, 2009). Brophy and Good (1986), for example, claim that different patterns of classroom socialisation (e.g., teacher-student or student-student interactions, actual instruction, teacher and student expectations etc.) can partially explain variation in students' learning and academic success. The term "script" as used by Schank and Abelson (1977) refers to culturally shared as well as personal knowledge regarding, for example, how persons act in particular situation, such as in a restaurant, or in a classroom (see also Kollar et al., 2007). Both teachers and learners have cognitive representations of typical lesson structures and sequences of learning activities in the classroom (Webb & Mastergeorge, 2003). We refer to the cognitive representations of typical lesson sequences as *classroom scripts* which guide both teachers and learners in their understanding and help them to act in specific classroom situations (see Seidel, Rimmele, & Prenzel, 2005). Classroom scripts can be seen as one mechanism by which teaching and learning practices are conveyed from one generation to the next, with future teachers internalising scripts over thousands of hours of experience as students (e.g., Britzman, 1991). That which can be observed in the classroom is the classroom interaction pattern, and this pattern is influenced by the classroom scripts of the participating learners and teachers as well as by the constraints and affordances of the instructional context at hand. In practice, classroom interaction patterns may well to a large extent be determined by the cognitive classroom scripts since mental representations have been found to be rather similar among the actors in a given instructional situation, and the constraints and affordances in western classrooms are impressively homogeneous and constant over time (Schratzenstaller, 2010).

Inquiry learning is seen as a rather student-centred form of learning in which students are actively involved in the construction of knowledge by building hypothesis, gathering evidences and interpreting results. However, teachers are often not well trained in embedding this innovative and student-centred form of learning into their lessons; a fact which might result from "technology assimilation", with the teacher being guided by their traditional classroom script and using materials for inquiry learning to support their own rather teacher-centred method of instruction (see Cognition and Technology Group at Vanderbilt, 1997, Slotta & Linn, 2009). Alternatively, this may be the result of a "replaced-by-technology" mindset, with the teacher activating a kind of spectator script as though they were attending the demonstration of a technology designed to take over the role of the instructor. A small-scale study on web-based inquiry learning, for example, found that the presence versus absence of a teacher in such a role does not even influence students' learning outcomes (Martiny, 2005). While the classroom interaction pattern arising when teachers assume such a passive role has not been analysed with respect to help seeking and help providing, it can be assumed that students also accept the new role distribution and thus refrain from asking for help from the observing teacher. We refer to this phenomenon as "expertise inhibition"; while the teacher possesses domain knowledge, the classroom-interaction pattern poses a barrier when it comes to teachers and learners making use of this knowledge. One might object that by offering a learning context in which learners have access to a variety of resources such as the internet, a learning environment, a learning partner, and the teacher, learners might actually be encouraged to seek content and strategy support when necessary. Research has, however, consistently shown that students are not good at seeking help in technology-enhanced learning environments, even if these environments offer all the content and strategy support needed (Aleven & Koedinger, 2000; Gräsel, Fischer, & Mandl, 2001).

Although systematically developed web-based inquiry-learning environments (e.g., WISE: Slotta & Linn, 2000; CoLab: Savelsbergh, van Joolingen, Sins, de Jong, & Lazonder, 2004) mostly include teacher instructions regarding how to embed the environment into the overall lesson structure, deeply rooted, incompatible cognitive classroom scripts might hinder teachers when it comes to implementing these ideas. Moreover, such externally represented classroom scripts or lesson plans have so far rarely been empirically tested with respect to their effectiveness. De Jong’s (2006) inquiry-learning model can serve as a prototypical inquiry classroom-script in which five phases of inquiry learning occur: (1) orientation, (2) hypothesis generation, (3) information collection, (4) conclusion drawing, and (5) evaluation. However, classroom-level (or plenary) instruction can further vary from being low- to high-structured. In a low-structured classroom script, students are primarily involved in self-directed and collaborative activities after receiving an introduction to the topic and navigation in the web-based environment. In a high-structured inquiry classroom-script, the teacher introduces, sequences, and evaluates learning activities. Typically, the teacher introduces the main inquiry activities in a sequenced fashion to the classroom plenary and gives instructions on how to proceed in the web-based environment before allowing students to work on one of the activities and return with their results to the classroom plenary. It has been argued that minimal guidance in inquiry-based teaching is less efficient with respect to domain learning (Kirschner, Sweller, & Clark, 2006). Classroom patterns are thus considered to differ in terms of promoting or hindering learning processes. So far, however, few studies have examined the effects of such patterns on help-seeking behaviour. Accordingly, the present study focused on how differently structured classroom scripts (high vs. low) affect both help-seeking processes in inquiry learning and learning outcomes with respect to domain knowledge.

2. Method

2.1. Sample and design

Participants were 108 16- to 19-year-old students who worked in pairs (N = 54 dyads) from the middle-track level of secondary education. Differences between high- and low-structured classroom scripts (i.e., structuredness) were implemented in the following way: (a) in a *high-structured classroom-script condition* (2 classes; n = 19 dyads), an inquiry-learning model was introduced to the students, and students' small-group activities were interrupted by teacher-led plenary activities following each of 5 inquiry phases and (b) in a *low-structured classroom-script condition* (3 classes; n = 35 dyads), the inquiry cycle was not introduced by the teacher, and students instead worked in pairs in the learning environment after having been informed about the environment structure. Participants were randomly assigned to one of those classroom-script conditions. Media-literacy skills were assessed prior to the actual learning phase (for more details on this assessment, see Wecker, Kohnle, & Fischer, 2007). Students were subsequently assigned to dyads that were homogeneous with respect to media literacy, and equal numbers of high- and low-media-literacy dyads were assigned to each condition. The participating teacher had not previously used computer-supported collaborative inquiry learning with these students, and students therefore had no prior experience of the approach.

2.2. Learning environment and the structuredness of the classroom script

2.2.1. WISE – web-based learning environment

The students in each dyad used a shared laptop computer. They worked on a module of the Web-based Inquiry Science Environment (WISE; Slotta & Linn, 2000). In WISE, the five phases of inquiry learning (de Jong, 2006) are embedded in the web-based learning environment (see Figure 1). The students' task was to test two contradicting hypotheses - "light dies out" versus "light goes forever" - by exploring various materials, such as texts, pictures, and short video clips. Students selected one of these two hypotheses and tested it using different sources of information offered by the online learning environment as well as using the graphical SenseMaker tool (Bell, 2004) in order to classify the evidence according to the hypothesis supported. Students were able to click on prompts in order to receive hints (seen as a help function) regarding the interpretation of the presented information, such as "*Think about something that is similar to attempting to see in a dark room. Why is it so difficult?*", and also concerning what they should do next, for example: "*Discuss with your partner*". The entire task comprised 130 minutes of study time in both conditions.

[Insert Figure 1 about here]

2.2.2. Implementation of the classroom script structuredness

In the *high-structured classroom-script condition*, the inquiry process was structured into the five teacher-initiated phases of inquiry learning. Each phase commenced at the plenary level, with the teacher giving an introduction and providing clear instructions on what was expected of the students in their dyadic inquiry. Each phase ended with an evaluation of the hypotheses, the results, and the findings which students had collected and formulated during their small-group work.

(i) *Phase of orientation and introduction of the learning environment* (15 min.). After a short power-point presentation on the topic "light propagation", the students were introduced by the teacher to the question: "How far does light go?". Students' prior knowledge was activated by questions regarding the introduced topic. WISE was subsequently introduced and the students were instructed to read and make notes on the two competing theses: "light dies out" versus "light goes forever".

(ii) *Phase of hypothesis generation* (5 min.) The students presented examples of the hypotheses which they formulated in pairs. They formulated assumptions and ideas on the propagation of light rays and gave their own opinions on the two competing ideas of how light propagates.

(iii) *Phase of information collection* (75 min.). Before the dyads began working independently with pieces of evidence provided in the context of the project, they were shown by the teacher how to cope with the available information. Using the first topic - "search light" - the five phases of the inquiry cycle were illustrated by means of an example (20 min.). The learners were made familiar with questions designed to help them organise their learning process within the five phases of the inquiry cycle (e.g., "What is the topic about?", "What do I already know about the issue?", "How are A and B connected?" etc.). Dyads then worked independently on the next topic - "on the soccer field", before presenting their results and receiving teacher feedback (20 min.). Pairs subsequently worked on their own in the WISE (35 min.).

(iv) *Phase of conclusion drawing* (15 min.). Students completed the final part of the project "How far does light go?" before being asked to decide which of the two competing hypotheses they favoured. Students wrote down three arguments which strongly supported their selected hypothesis and three arguments which were against it or not quite clear. The learners wrote down their arguments on cards of two different colours.

(v) *Phase of evaluation* (20 min.). The students presented their arguments for and against the original hypotheses: "light dies out" versus "light goes forever" in the classroom plenary. Dyads' approaches to working in the learning environment were evaluated and discussed. Successful strategies were compared with less successful strategies and suggestions for improvements were considered.

In the *low-structured classroom-script condition*, the inquiry process was not introduced by the teacher at the plenary level, and students were instead informed about the structure of the web-based learning environment and the task before working in pairs in the learning environment without any plenary phases. However, the web-based learning environment presented students in this condition with the same domain information as well as the same information on the different steps in the inquiry process.

At the end of the inquiry-learning session, a plenary discussion was led by the teacher in both conditions. Both script conditions were designed based on the model of inquiry learning and did not specifically aim to support help seeking. During the lessons and data collection, the teacher was not aware of this research focus. She was instructed to follow the procedure outlined in the classroom script, but no other instructions were provided regarding how she should behave in the classroom. In both conditions, the teacher was available during the sessions and walked around the classroom in a non-systematic manner while students were working in dyads.

2.3. Instruments

2.3.1. Analysis of the help-seeking process

Nelson-Le Gall's (1981) model of the help-seeking process was applied in a quantitative analysis of 54 screen-capture and audio videos of the first lessons. Development of the coding scheme was theory driven (Nelson-Le Gall, 1981) and adapted to the specific data under analysis. This scheme included six dimensions. Using a time-sampling method, four five-minute intervals (from the beginning of the video in minutes 25.00-30.00; 40.00-45.00; 55.00-60.00; 70.00-75.00) were randomly selected from the 90-minute videos and analysed.

We started by identifying points at which students indicated a need for help (e.g., by directly asking for help or expressing a lack of understanding). These included, for example, expressions such as “What should we do now?”, “Is this right?”, “What?”, or “I do not understand this”. Then the coding process was conducted as follows: First, analyses focused on the source from which help was sought as a *source of help* (teacher/fellow learner/other student/WISE). Using the computer as a source of help was possible by clicking on prompts which gave hints when students were unsure about how to progress with the task in WISE. Second, the *content of help sought* was examined, such as domain knowledge, inquiry learning, and technical problems. Asking for help in connection with domain knowledge included questions such as "Is my solution right?" or statements such as "I do not understand this". Help sought with respect to the inquiry process included questions such as "How do I formulate the hypothesis?". Questions regarding technical help were related to the function of the computer and the software in use. Third, *the quality of help sought* was coded with respect to whether it was executive or instrumental. Executive help refers to students seeking direct answers, for example, "Is this right?", whereas instrumental help entails no direct answers being sought but rather hints and guidance on how to figure out the problem for themselves, for example, "Could you give me a hint?". Fourth, the data was coded according to the *type of help received*: executive (receiving complete answers, helper takes over and solves the task or writes a solution) versus instrumental (explanations, hints). Fifth, *the usage of the help received* was analysed. Help was used, for example, if students followed the instructions given by a help giver, entered the information they had received, performed the "drag and drop" action based on the help they had received, and so forth. Not using the help received was coded if students did not attempt to follow the given instructions. Sixth, the *solution of a problem* was coded in terms of whether students solved the problem based on the help they had received. The problem was coded as solved if the students were, for example, able to write down the hypothesis in the appropriate text box, open up the video after having had problems with it, perform the "drag and drop" action in the SenseMaker, and so forth. A problem was coded as still existing if students failed to take the actions required to solve a problem, for example, failing to write down a hypothesis, enter text in their diary, perform the "drag and drop" action, and so forth. We analysed the data at the pair level (in contrast to the individual learner). Interrater agreement of two coders for coding of the help-seeking process (determined based on 10% of the data) ranged between 74% - 98%.

2.3.2. Domain knowledge

Students' *knowledge of physics* was measured on an individual basis in identical pre- and post-tests. The domain-knowledge test, which was specifically developed based on the content of the WISE, comprises distinct scales which measure different curriculum aspects (Bell, 2004). For the purpose of the present study, seven multiple-choice items (one point for each correct answer) and three items with a free-response format (0-2 points from the answer) were applied. Scores ranged from 0 to 13. The multiple-choice items covered information which the students were supposed to collect while working in the online learning environment, for example, "*Telescopes can be used to observe things, such as the moon. Which of the following explanations best describes how a telescope works?*". The multiple-choice items contained four options, for example, "*A telescope gets you closer to the moon.*" A free-response format was used to assess the correctness of students' understanding of the respective scientific phenomenon and to ascertain whether they held any misconceptions, for example, that light can be "absorbed" by "other light", with higher values indicating fewer misconceptions. It should be noted that the information required in the domain-knowledge test had been available to all students in the online learning environment. Information provided by the teacher was equivalent to that provided in WISE. Domain-knowledge gains were calculated based on the mean score of the two individuals in each dyad (see Cress, 2008) and were specifically computed as the mean score of a dyad (the sum of the two students' scores divided by two) in the post-test minus the mean score of a dyad (the sum of the two students' scored divided by two) in the pre-test. Resulting domain-knowledge gains were thus either positive or negative. Internal consistencies were satisfactory, with Cronbach's $\alpha = 0.74$ in the pre-test and $\alpha = 0.80$ in the post-test. Interrater agreement between the two coders for the open items ranged from 86% to 99%.

2.4. Statistical analysis

Dyads served as the unit of analysis. The Mann-Whitney test (with Monte Carlo exact test) was used to compare the two classroom-script conditions with respect to domain-specific knowledge (pre- and post-test), domain-learning gains, and relative frequencies of help-seeking variables. The level of significance was set to 95%. Non-parametrical tests were employed due to ANOVA prerequisites not being met.

3. Results

3.1. *Preliminary data analysis*

There was no difference between classroom-script conditions with respect to prior knowledge, $U = 276.00$, $z = -1.06$, $p > .20$, $r = -.14$ (see also Table 2). In the high-structured classroom-script condition, collaborative pair-work comprised 36% and teacher-led activities 64% of the total sampling time. In contrast, pair work comprised 94% and teacher-led activities only 6% of the total sampling time in the low-structured classroom-script condition.

3.2. *Help-seeking in differently structured classroom-script conditions*

We first investigated the effects of classroom-script structuredness (high vs. low) on help-seeking processes in the collaborative inquiry-learning environment. The amount of help sought (the unit of single help-seeking) was generally rather low across all experimental conditions. Each dyad sought help approximately three times ($M = 3.15$, $SD = 2.64$; min. 0 times and max. 10 times) across the four five-minute time samples. This frequency was lower in the high-structured ($M = 1.79$, $SD = 1.75$) as compared with the low-structured classroom-script condition ($M = 3.88$, $SD = 2.76$). This difference proved significant, $U = 174.00$, $z = -2.90$, $p < .01$, $r = -.39$.

3.2.1. Source of help sought

In both conditions, students were able to seek help from the fellow learner in their dyad, from the teacher, from other students, and from WISE (via prompts offered by the environment). When seeking help, students in both conditions most frequently (65% and 68%) turned to the *fellow learner* in their dyad, yielding a non-significant group difference, $U = 225.00$, $z = -.15$, *ns*, $r = -.02$ (see Table 1). Of the total amount of help sought, 17% was sought from the *teacher* in the high-structured classroom-script condition and 14% in the low-structured classroom-script condition. This difference was not statistically significant, $U = 206.50$, $z = -.68$, *ns*, $r = -.10$. Only 6% of the total amount of help sought was sought from *other students* in the low-structured condition, whereas students in the high-structured condition did not seek help from other students in any of the four five-minute samples. Again, this difference was not significant, $U = 175.00$, $z = -1.99$, *ns*, $r = -.29$. Roughly 15% of the total amount of help sought in both conditions was sought from *WISE*. However, students in the high-structured classroom-script condition turned to WISE for help less frequently than those in the low-structured classroom-script condition (see Table 1). This difference between the conditions was statistically significant, $U = 146.00$, $z = -2.39$, $p < .05$, $r = -.35$.

3.2.2. Content of help sought

Three different kinds of content-related help were analysed: domain knowledge, inquiry learning, and technical problems. Help relating to *domain knowledge* constituted 11% of the total amount of help sought in the high-structured classroom-script condition and 44% in the low-structured classroom-script condition (see Table 1). This difference was significant, $U = 94.50$, $z = -3.29$, $p < .01$, $r = -.48$. In the low-structured condition, students asked for less help concerning *inquiry learning* (almost 32% of help sought) as compared with students in the high-structured classroom-script condition (approximately 60%). However, this difference was not significant, $U = 152.00$, $z = -1.87$, *ns*, $r = -.27$. Help sought for *technical problems* accounted for 29% of the help sought in the high-structured classroom-script condition compared with 24% of that sought in the low-structured classroom-script condition*,* U = 225.00, z = -.15, *ns*, r = -.02.

3.2.3. Quality of help sought

With respect to the quality of help sought, students in both conditions more frequently asked for *executive help* than *instrumental help*. Executive help accounted for 100% of the total amount of help sought in the high-structured classroom-script condition and 98% in the low-structured classroom-script condition, U = 215.00, z = -.64, *ns*, r = -.09. Students very rarely sought *instrumental help,* U = 196.00, z = -1.52, *ns*, r = -.22. Differences between conditions with respect to the quality of help sought were not significant.

3.2.4. Type of help received

Two types of help were received: executive and instrumental. With regard to the relative amount of *executive help received*, students in the high-structured classroom-script condition (approximately 81% of help received) did not significantly differ from those in the low-structured classroom-script condition (83%), U = 187.50, z = -.13, *ns*, r = -.02. *Instrumental help* accounted for 19% of the help received in the high-structured classroom-script condition and 17% in the low-structured classroom-script condition. Again, this difference was not significant, U = 187.50, z = -.13, *ns*, r = -.02.

3.2.5. Usage of help received

Students in both conditions utilised the help received more often than they ignored it or avoided using it. Students in the high-structured classroom-script condition made more frequent use of the help received (93%) as compared with those in the low-structured classroom condition (83%). However, this difference was not significant, U = 122.50, z = -1.27, *ns*, r = -.19. Students in the low-structured classroom condition accordingly also ignored the help received (*help not used*) more often than those in the high-structured classroom condition. In the low-structured classroom-script condition, 17% of the help received was not used compared with only 7% in the high-structured classroom-script condition. This difference was not significant, $U = 122.50$, $z = -1.27$, *ns*, $r = -.19$.

3.2.6. Problem solution

Students in both conditions *solved most of the problems* after receiving help. In the high-structured classroom condition, 83% of problems were solved compared with 79% in the low-structured classroom-script condition. This difference was non-significant, $U = 188.50$, $z = -.09$, *ns*, $r = -.01$. These results show that problems continued to exist after students had asked for and received help. These *problems continuing to exist* after help had been received accounted for 17% of all problems in the high-structured classroom-script condition compared with 21% in the low-structured classroom-script condition. This difference was not significant, $U = 175.00$, $z = -.50$, *ns*, $r = -.07$.

[Insert Table 1 about here]

3.3. *Domain-knowledge gains in differently structured classroom-script conditions*

In a second line of analyses, we investigated the effects of classroom-script structuredness (high vs. low) on the domain-knowledge-related learning outcomes of a collaborative inquiry-learning environment. Overall, students showed an increase in domain knowledge. Students in the high-structured classroom-script condition, however, showed greater gains than those in the low-structured classroom-script condition (see Table 2). This difference was significant, $U = 219.00$, $z = -2.15$, $p < .05$, $r = -.29$.

[Insert Table 2 about here]

4. Discussion

Web-based inquiry learning represents a challenging task for learners. Compared with traditional science-learning environments, appropriately working on inquiry tasks is considered to have the potential to promote highly appreciated kinds of knowledge and skill to a far greater degree (see Linn, Lee, Tinker, Husic, & Chiu, 2006). Our study demonstrates greater effectiveness of the inquiry classroom-script with higher levels of teacher control and guidance in promoting domain-knowledge gains (see also Kirschner et al., 2006). With regard to help seeking, our results further provide evidence of a generally low frequency of appropriate help-seeking behaviour when learning in the web-based inquiry-learning classroom. Students hardly sought any help from their teacher and made only sparse use of the resources that were available in the web-based environment (see Aleven et al., 2003). Despite being more likely to seek help from their fellow learners, students very rarely requested instrumental help - the very type of help that is known to be strongly associated with learning gains (Nelson-Le Gall, 1981; Webb et al., 2006). The type of help received by students largely mirrored the type of help they had requested. While students generally exhibited low levels of help-seeking behaviour in both conditions, students in the high-structured classroom-script condition with higher levels of teacher guidance sought less help at the same time as learning more than students in the low-structured classroom-script condition. This pattern might be explained by a low level of student help-seeking skills and a reduced need for such skills in the highly structured inquiry-learning environment. In environments with a high level of structure, students are able to focus on understanding and do not have to allocate cognitive resources (Kirschner et al., 2006) to help-seeking processes that are generally ineffective due to a lack of high-level help-seeking skills.

In the more student-centred and open classroom script in which students hardly sought help from the teacher, an effect occurred that might be referred to as “expertise inhibition”.

This term reflects the obvious barriers affecting both the teacher and learners when it comes to making use of the teacher's domain expertise. One of these barriers may comprise students' mental scripts which stem from their earlier experiences of group work; experiences which are probably characterized by independent group work, as is often the case in Western culture (see Karabenick & Newman, 2009). In order to fully make use of the potential of web-based collaborative inquiry learning, it would seem necessary to identify and further develop external classroom scripts that more effectively embed web-based inquiry learning and which adjust the support provided at different instructional levels (Tabak, 2004). Such classroom scripts should include a focus on developing help-seeking and help-giving skills and should also be targeted towards unleashing the teacher's expertise without returning to expository teaching patterns.

One potential limitation of the study is the population from which the participant sample was drawn. The study was conducted at the middle-track level of secondary education, where students' learning skills and ability are probably weaker than is the case in upper-track secondary schools (where studies on help-seeking behaviour have typically been conducted so far; see prior achievement; Ryan & Shin, this issue). Our participants may represent students who require a high level of support and guidance and who therefore only benefit from more teacher-led phases, whereas potential future participants with a greater learning capacity might be better able to tap into the potential of the more self-directed and collaborative phases (see also Azevedo, 2001). A follow-up experiment could test the interaction hypothesis that learners with better learning prerequisites benefit more from the low-structured classroom script and those with lower prerequisites benefit more from the high-structured classroom script. It might also be that students who have none or little experiences with web-based inquiry learning in collaborative situations (complex task, lack of collaboration and inquiry skills) are not able to show high levels of help-seeking behaviour because of cognitive overload (Oortwijn, Boekaers, Vedder, & Strijbos, 2008).

There are further potential limitations of this study. First, the sample size was somewhat limited, in particular when taking into account that the unit of analysis (or more specifically, the unit of aggregation) was the dyad. Furthermore, only five classes participated and it was not possible to implement both classroom-script conditions in one and the same class. A confounding relationship between classroom script and the specific features of the classes involved in the study thus can not be completely ruled out. In addition, learning physics in secondary school is a context with several specific features that do not easily generalise to other contexts. Future research demands are thus to replicate the findings with larger samples including several classes that can be randomly assigned to conditions and to replicate the observed effects in different contexts.

For educational practice it can be concluded that bringing web-based inquiry learning into the science classroom requires more than just theory-guided development of inquiry software and a set of laptops if it is to be effective for learning. Without embedding the technology into an appropriate inquiry classroom-script, the effects on learning processes and outcomes may well be sub-optimal. At least with learners from lower-track secondary schools (and probably other learners with lower learning prerequisites), appropriate classroom scripts should offer a higher degree of structure and assign the teacher to specify the inquiry learning steps at the whole-classroom plenary level.

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Figure Caption

Figure 1. Screen capture showing the WISE project “How far does light go?” and one of the cognitive hints: “*Why can we see the person dressed in white better than the person dressed in black - what happens to the light?*” (viewed as a help function for students).

Table 1

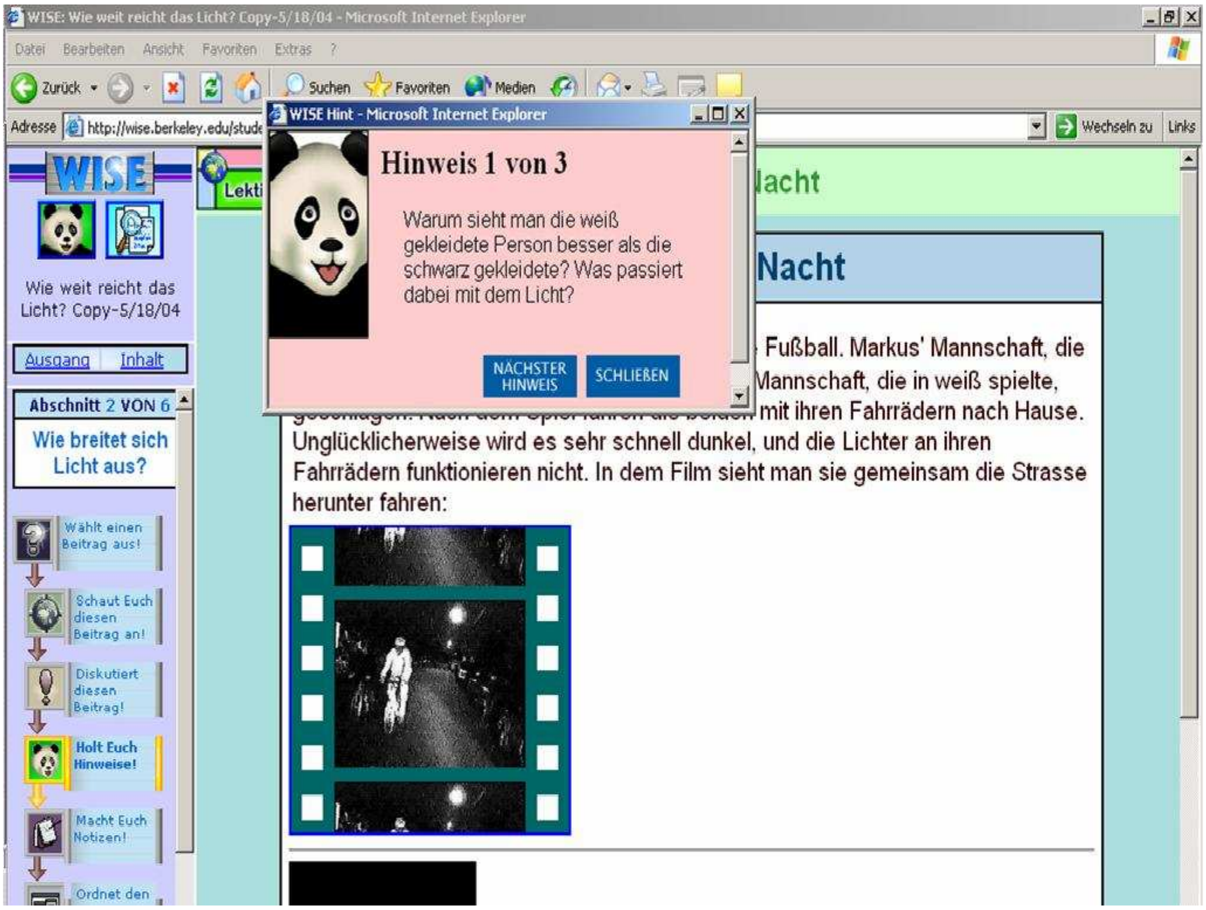
Means, standard deviations, percentage, mean rank, sum of ranks and p-values of help-seeking variables in different classroom-script conditions

	Structuredness of classroom script						
	High			Low			
Help-seeking variables	*M* (*SD*)	**%**	Mean Rank (Sum of Ranks)	*M* (*SD*)	**%**	Mean Rank (Sum of Ranks)	***P***
Source:							
Fellow learner	1.37		24.43	3.03		23.82	
	(1.50)	68.22	(342.00)	(2.61)	65.05	(786.00)	.89
Teacher	0.31		25.75	0.37		23.26	
	(0.48)	17.11	(360.50)	(0.64)	14.37	(767.50)	.51
Other student	0.00		20.00	0.26		25.70	
	(0.00)	0.00	(280.00)	(0.51)	6.14	(848.00)	.08
WISE	0.16		17.93	0.66		26.58	
	(0.37)	14.67	(251.00)	(1.00)	14.43	(877.00)	.02
Content of help sought:							
Domain knowledge	0.37		14.25	1.80		28.14	
	(1.16)	10.51	(199.50)	(1.62)	43.65	(928.50)	.00
Inquiry learning	0.89		29.64	1.43		21.61	
	(0.94)	60.13	(415.00)	(1.68)	31.72	(713.00)	.06
Technical problems	0.47		24.43	0.66		23.82	
	(0.70)	29.36	(342.00)	(0.80)	24.62	(786.00)	.89
Quality of help sought:							
Executive	1.74		25.14	3.71		23.52	
	(1.79)	100.00	(352.00)	(2.51)	97.92	(776.00)	.65
Instrumental	0.45		21.50	0.17		25.06	
	(0.00)	0.00	(301.00)	(0.00)	2.08	(827.00)	.27
Type of help received:							
Executive	1.21		22.13	2.80		22.64	
	(1.31)	80.56	(265.50)	(2.17)	82.97	(724.50)	.90
Instrumental	0.26		22.88	0.51		22.36	
	(0.45)	19.44	(274.50)	(0.70)	17.02	(715.50)	.90
Usage of help received:							
Help used	0.84		25.25	2.71		20.33	
	(1.01)	92.50	(252.50)	(2.16)	82.54	(650.50)	.23
Help not used	0.10		17.75	0.54		22.67	
	(0.31)	7.50	(177.50)	(0.78)	17.46	(725.50)	.22
Solution:							
Problem solved	1.21		22.79	2.60		22.39	
	(1.31)	82.73	(273.50)	(1.96)	79.11	(716.50)	.93
Problem continuing to exist	0.37		21.08	0.88		23.03	
	(0.83)	17.27	(253.00)	(1.28)	20.89	(737.00)	.62

Table 2

Means, standard deviations, mean rank, sum of ranks and p-values of pre-test, post-test, and domain-knowledge gains in differently structured classroom-script conditions

	Structuredness of the classroom script				
	High		**Low**		
	M (*SD*)	Mean Rank (Sum of Ranks)	*M* (*SD*)	Mean Rank (Sum of Ranks)	*p*
Pre-test	0.97	24.53	1.36	29.11	
	(1.12)	(466.00)	(1.33)	(1019.00)	.29
Post-test	1.58	29.63	1.47	26.34	
	(1.16)	(563.00)	(1.45)	(922.00)	.47
Domain gain	0.60	33.47	0.11	24.26	
	(0.96)	(636.00)	(0.89)	(849.00)	.03


WISE: Wie weit reicht das Licht? Copy-5/18/04 - Microsoft Internet Explorer
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Hinweis 1 von 3
Warum sieht man die weiß gekleidete Person besser als die schwarz gekleidete? Was passiert dabei mit dem Licht?
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Wählt einen Beitrag aus!
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Diskutiert diesen Beitrag!
Holt Euch Hinweise!
Macht Euch Notizen!
Ordnet den
Lekti
Nacht
Nacht
Fußball. Markus' Mannschaft, die
Mannschaft, die in weiß spielte,
mit ihren Fahrrädern nach Hause.
Unglücklicherweise wird es sehr schnell dunkel, und die Lichter an ihren Fahrrädern funktionieren nicht. In dem Film sieht man sie gemeinsam die Strasse herunter fahren: