Are core objectives of web-based collaborative inquiry learning already core learning prerequisites? The case of argumentation competences and computer literacy

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Abstract: We investigated whether argumentation competence and computer literacy, which are typically regarded as goals of web-based collaborative inquiry learning, also constitute important learning prerequisites for the acquisition of domain-specific knowledge. Results of two empirical studies showed that learners with higher argumentation competence and learners with lower computer literacy acquired more domain-specific knowledge. Core objectives of collaborative inquiry learning can be influential prerequisites as well, albeit not always in the way that may be expected.

Collaborative inquiry learning is recognized as a powerful way to enable students to acquire scientific concepts. It requires them to conduct activities similar to those of scientists. From a socio-cultural perspective, it is expected that, through their participation in scientific activities, students develop domain-general competences such as argumentation competence. One further advantage of web-based collaborative inquiry learning environments is that they may foster students' computer literacy. In two studies we investigated to what extent these two domain-general competences also constitute important learning prerequisites for domain-specific knowledge acquisition.

Study 1: Argumentation in inquiry learning – prerequisite and outcome?

Argumentation competence comprises the ability to understand and produce sophisticated single arguments and argument sequences. According to Toulmin's (1958) argument scheme or simplified variants of it, sophisticated single arguments have certain structural components such as claims, data and reasons. According to the model of Leitão (2000), an argumentation sequence particularly beneficial for collaborative learning should consist of argument, counterargument, and integration. We subsume these aspects of argumentation competence under the concept of "internal scripts on collaborative argumentation". Schank (1999) viewed scripts as individual memory structures that guide individuals in acting in and understanding specific situations. In terms of the structural and the sequential model of argumentation, individuals with high structured *internal scripts on collaborative argumentation* should be more capable of constructing arguments containing data, claims, and reasons as well as in producing counterarguments and integrative arguments than individuals with low structured internal scripts. As inquiry learning as strongly requires learners to engage in collaborative argumentation, our hypothesis for study 1 was that learners exhibiting a high structured internal script on collaboration argumentation prior to the inquiry learning session will acquire more domain-specific knowledge than learners exhibiting low structured internal scripts.

Method

Participants and Design. Participants in this study were 46 students from grades 8 to 10 from secondary schools. We compared two conditions from a larger study (Kollar, Fischer & Slotta, 2005) with students with a high vs. low *degree of structuredness of their internal scripts on collaborative argumentation*. The degree of structuredness of the internal scripts was assessed by a test based on simplified Toulmin and Leitão models of argumentation (Cronbach's α = .61). Using a median-split, we identified 24 learners with a high structured internal script and 22 learners with a low structured internal script on collaborative argumentation. Participants in each of the two groups were coupled homogeneously with respect to gender and to their internal scripts' degrees of structuredness.

Procedure. In a first session of about 45 minutes, learners were asked to complete several questionnaires for their domain-specific prior knowledge and the degree of structuredness of their internal scripts. In the second session (two weeks later) the learners received a short technical introduction, collaborated in dyads for 120 minutes on a German version of the unit "The Deformed Frogs Mystery" from the WISE environment. There, the learners faced two competing hypotheses explaining why so many frogs were deformed in the nineties in the U. S. Their task was to discuss the two hypotheses against the background of evidence presented in the environment. On several occasions, they were asked to discuss the two hypotheses against the background of the information they just had reviewed and to type their ideas into a text box. Finally they individually completed a post-test,for their domain-specific knowledge. Each dyad shared one computer.

Instruments. *Processes of collaborative argumentation* were analyzed based on ten samples of five minutes from each transcription of the dialogues during the inquiry unit. Transcriptions were first coded for the occurrence of argumentative or non-argumentative talk (Cohen's $\kappa = .78$). Then two coders independently from each other identified single arguments. Each argument was rated for its structure as low, medium, or high (Cohen's $\kappa = .68$). The *outcomes of collaborative argumentation* were assessed by the same test for domain-specific knowledge before and after collaboration. It included five open-ended questions about mechanisms assumed in the two hypotheses, empirical evidence, and plans concerning how to decide what caused the deformities (Cronbach's $\alpha = .58$).

Results

On the *process* level, dyads with high structured internal scripts produced more arguments than dyads with low structured internal scripts ($t(11.33) = 3.32$; $p < .01$). Learners with high structured internal scripts produced more arguments with medium ($t(14.42) = 3.32$: $p < .01$) and high ($t(15.57) = 3.41$; $p < .01$) levels of structure than learners with low structured internal scripts, but about the same amount of arguments with low structure ($t(20) = 0.60$; *n.s.*). On the *outcome* level, learners with high structured internal scripts outperformed learners with low structured internal scripts on the post-test for domain-specific knowledge ($F(1,43) = 4.64$, $p < .05$, $Eta^2 = .10$).

Study 2: Computer literacy in web-based inquiry – prerequisite and outcome?

According to assumptions about a so-called "second-level digital divide", people's computer literacy may affect their chances to acquire knowledge from digital media (Hargittai, 2002). In this study, we focuss on familiarity with computers as one aspect of computer literacy (Richter, Naumann, & Groeben, 2001). Typically, web-based inquiry learning environments require learners to engage in two types of media-related activities. On the one hand, learners are required to engage in active processing of *media elements for receptive use*, such as text, pictures or films. On the other hand, they are often provided with the opportunity to actively manipulate *media elements for productive use*, such as the so-called SenseMaker in many WISE environments, in which students can sort evidence according to the claim it supports by drag-and-drop manipulation. To benefit from such elements, learners need to have actively processed the content of elements for receptive use in which the evidence is presented (Kintsch, 1998). As it can be expected that students with a high level of computer literacy exhibit a more effective pattern of media use in a sense that they are more capable in adopting adequate strategies for both the receptive and the productive use of media elements, our hypothesis for study 2 was: Learners with higher computer literacy will acquire more domain-specific knowledge than learners with lower computer literacy.

Method

Participants and Design. The participants were 37 students from a secondary school; 15 fulfilled the criteria for inclusion in the analysis. The design compared students with high vs. low *computer literacy*. This was assessed by a seven items (Cronbach's $\alpha = .83$) adaptation of the subscale "familiarity with computers" from the German computer literacy inventory (INCOBI; Richter et al., 2001). The median of 0.43 was used for a split. 8 participants had high and 7 had low computer literacy. Dyads were homogeneous in gender, but not computer literacy.

Procedure. On the first day, learners filled in several questionnaires, including tests of prior domain-specific knowledge and familiarity with computers. Then they received an introduction to the learning environment, and collaborated in dyads on a German version of the WISE unit "How far does light go". Again, they faced two competing hypotheses they were supposed to discuss against the background of evidence presented in the learning environment. For example, they could view pages with text, pictures and films (media elements for receptive use), and use notepad windows and the SenseMaker tool to document their findings (media element for productive use). On the second day, dyads continued collaboration and finally completed a post test for domain-specific knowledge. Again, each dyad shared one computer

Instruments. The main dependent variable was the learners' *domain-specific knowledge* gains from pre- to post-test, as measured by an adapted version of a test specific for this unit (Cronbach's $\alpha = .77$ in the post-test). We analyzed the *patterns of media use* by coding segments (10sec each) from screen recordings of the learning processes with respect to the media element displayed (receptive, productive, or other; Cohen's $\kappa = .75$).

Results

With respesct to *domain-specific knowledge* we found an unexpected result: Learners with high computer literacy had higher domain-specific knowledge gains than learners low computer literacy ($t(13) = 2.60$, $p < .05$). Correspondingly, we observed a substantial negative correlation between computer literacy and knowledge gains ($r = -.54$, $p < .05$). To explain this surprising finding, we analyzed the *patterns of media use* on a single case basis. In one prototypical dyad with high computer literacy, we observed a tendency to quickly rush through the environment and to focus mainly on media elements for productive use. In contrast, in a prototypical dyad with low computer literacy, the students proceded at a lower pace, often going back and forth between media elements for re-discussion. This may indicate that they elaborated the material more deeply than the first dyad, which might be an important precondition to successfully interact with media elements for productive use. They also distributed their attention over media elements for receptive and productive use more evenly (Wecker, Kohnle & Fischer, in press).

General discussion

The two studies show that argumentation competence and computer literacy, which both can be regarded as core learning objectives of web-based collaborative inquiry learning environments, also play a role as individual learning prerequisites for domain-specific knowledge acquisition. Both domain-general competences were found to influence the amount of domain-specific knowledge acquired by the students. Learners with less sophisticated argumentation competences may be disadvantaged with this learning approach without further instruction. However, higher competence levels do not always guarantee higher learning gains: Higher computer literacy may be associated with worse outcomes in terms of domain-specific knowledge acquisition lower computer literacy. Our analysis of the patterns of media use reveals possible explanations for this surprising finding. It appears that learners with a high level of computer literacy may easily transfer their usual web-browsing behaviour to web-based collaborative inquiry learning environments, in which a more profound elaboration of information would be necessary. Additionally, they seem to be attracted a lot by media elements that afford active manipulation, but often use them without deep elaboration of the learning material. – From our perspective, these results lead to at least three important consequences. First, theory-building on inquiry learning should focus more on individual learner characteristics that may influence the success of inquiry learning. Second, designers should try to explore ways how to design web-based collaborative inquiry learning environments that accommodate learners with a variety of individual competence profiles based on online-assessments of individual competences. Third, teachers need to find out about their students' competence profiles and to decide for which inquiry activities they need support. To guide teachers in this challenging task, we need theoretical accounts and aligned empirical research on the question how individual learning prerequisites, the use of digital media, and teaching behaviors must be "orchestrated" (Fischer & Dillenbourg, 2006) in order to accommodate heterogeneity among students.

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