

# Computer-Supported Collaborative Learning in Higher Education: Scripts for Argumentative Knowledge Construction in Distributed Groups

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**Abstract.** Learners rarely know how to construct knowledge together in argumentation. This experimental study analyzes two computer-supported collaboration scripts, which should facilitate processes and outcomes of argumentative knowledge construction. One script aims to support the construction of single arguments and the other script aims to support the construction of argumentation sequences. Both scripts were varied independently in a 2×2-factorial design. 120 students of Educational Science participated in the study in groups of three. Results show that the computer-supported scripts facilitate specific processes and outcomes of argumentative knowledge construction. Learners with scripts argued better and acquired more knowledge on argumentation than learners without scripts without impeding acquisition of domain specific knowledge.

**Keywords:** argumentative knowledge construction, computer-supported collaboration scripts

## OBJECTIVES

University students are supposed to become experts within a specific domain. In this regard, students are meant to be able to both understand and participate in argumentative discourse in their field. Even though knowledge on argumentation start to develop from an early age (Stein & Bernas, 1999), studies showed that adults' knowledge on argumentation are often suboptimal (e.g., Kuhn, 1991). Adults hardly base their claims on grounds and rarely consider counterarguments. Even though students may in general acquire domain-specific knowledge, they hardly seem to learn how to argue based on this knowledge within their domain.

An important opportunity for the development of knowledge on argumentation is the active participation in high-quality argumentative discourse in instructional settings (Kuhn, 1991). Regular classroom settings rarely foresee opportunities for learners to engage actively and equally in high-quality argumentative discourse (Cohen & Lotan, 1995). High-quality argumentative discourse in instructional settings means that collaborative learners construct formally and content adequate arguments while jointly working on a learning task. Computer-supported collaborative learning (CSCL) may provide an ideal context for this kind of discourse (Marttunen & Laurinen, 2001). During CSCL, students may construct and exchange arguments online that can be examined and evaluated by learning partners for longer periods of time than in face to face situations. Collaborative learners may thus elaborate the learning material by constructing arguments themselves to promote their perspective on one hand and on the other integrate arguments of their learning partners in their own perspective. In this way, learners may lead a high-quality online argumentative discourse with regard to formal aspects and contents and acquire domain-specific knowledge as well as knowledge on argumentation (see Andriessen, Baker, & Suthers, 2003; Weinberger & Fischer, in press).

The goal of this study is to implement CSCL within a university curriculum of educational science and to investigate how processes as well as outcomes of argumentative knowledge construction can be facilitated by means of computer-supported scripts within this CSCL environment.

## ARGUMENTATIVE KNOWLEDGE CONSTRUCTION

Argumentative knowledge construction means that learners construct arguments within a specific domain with the goal to acquire knowledge (Weinberger & Fischer, in press). First, we will portray potential outcomes of argumentative knowledge construction. Second, we will describe the processes of argumentative knowledge construction and how they may facilitate specific outcomes.

Argumentative knowledge construction aims to foster at least two different *outcomes*, namely domain-specific knowledge as well as knowledge on argumentation (Andriessen et al., 2003).

*Knowledge on argumentation* comprises knowledge on how to construct formally complete arguments with the components claim, ground and qualifier (*knowledge on the construction of single arguments*) and the knowledge on how to construct specific sequences of arguments consisting of arguments, counterarguments and integrations (*knowledge on the construction of argumentation sequences*).

*Domain-specific knowledge* in the context of this study means to be able to apply concepts from a specific theory that is to be learned. Learners constructing formally and content adequate arguments activate their prior knowledge, elaborate the given learning material, and thus construct new domain-specific knowledge (Andriessen et al., 2003).

The *processes of argumentative knowledge construction* are allocated on at least two dimensions, namely the formal argumentative dimension, regarding the formal structure of arguments and argumentation sequences, and the epistemic dimension, regarding the contents of the single arguments (Weinberger & Fischer, in press). On the *formal argumentative dimension*, the construction of single arguments and the construction of argumentation sequences consisting of more than one single argument can be differentiated.

A *single argument* has been regarded as a claim which can be supported by grounds and/or specified by qualifier (Toulmin, 1958). Grounds may justify the claim through a warrant. The qualifier limits the validity of the claim. Toulmin's model seems to be feasible to give an account on the quality of single arguments on formal as well as domain-specific levels. Furthermore, the model can be applied in different domains for constructing arguments based on uncertain information. Constructing arguments with these elements facilitates self-explanation of the learning material (Baker, 2003). Self-explanation is supposed to facilitate the integration of new knowledge into existing cognitive structures. Learners prompted to give self-explanations acquired more knowledge than unsupported learners (Chi, DeLeeuw, Chiu, & LaVancher, 1994).

Specific *argumentation sequences* have been regarded as an indicator for the construction of knowledge (Leitão, 2000). First, learners construct arguments to justify their position. This construction of arguments facilitates self-explanation of the learning material (see Baker, 2003). Second, learning partners construct counterarguments to challenge and reconsider these positions. *Counterarguments* facilitate meta-cognitive activities, prompting learners to rethink their initial argument (Leitão, 2000). Finally, learners construct replies and eventually refine the initial positions. By balancing arguments and counterarguments in order to solve complex problems, participants may acquire knowledge on argumentation and domain-specific knowledge.

The *epistemic dimension* regards how learners work on the learning task, what (theoretical) concepts they consider and how they may construct knowledge. Beyond formal aspects of argument construction, the contents learners use to construct arguments supposedly play a crucial role in argumentative knowledge construction (Kuhn, Shaw, & Felton, 1997). It has been found that learners in problem-oriented learning environments need to apply those theoretical concepts, which they are supposed to learn (*application of new knowledge*) in order to acquire domain-specific knowledge (Fischer, Bruhn, Gräsel, & Mandl, 2002; Weinberger, 2003). Beyond applying new knowledge, *application of prior knowledge* has been regarded as important to the acquisition of domain-specific knowledge, e.g., in problem-oriented learning environments of medical education (Schmidt, 1993). The amount of activated prior knowledge is supposed to influence how much new knowledge can be acquired. Students construct meaning by using their prior knowledge in the sense that new knowledge needs to be meaningfully related to existing bodies of knowledge (Anderson & Pearson, 1984).

## USING COMPUTER-SUPPORTED COLLABORATION SCRIPTS TO FACILITATE ARGUMENTATIVE KNOWLEDGE CONSTRUCTION

A central topic of CSCL research is how argumentative knowledge construction can be facilitated. Different approaches are being investigated. One prominent approach is *visualization*, which uses software tools and different representations to guide argumentative knowledge construction. Interfaces with different representational aids such as graphs, matrices or texts were found to have different effects on CSCL (Suthers & Hundhausen, 2001). Software tools, may visualize the argumentation of learners (Kirschner, Buckingham Shum, & Carr, 2003). For instance, diagrammatic representations visualize how arguments are related to each other and thus facilitate and guide learners' awareness of the argumentative discourse (Hoppe, Gaßner, Mühlenbrock & Tewissen, 2000). Tools like SenseMaker (Bell, 1997) support learners to represent their arguments by providing spaces and categories to group arguments and differentiate claims from evidence.

Another approach to facilitate argumentative knowledge construction is to realize *computer-supported collaboration scripts* based on O'Donnell's (1999) scripted cooperation approach. Scripts can be implemented into the communication interface of CSCL learning environments as kind of a guideline. They can interactively suggest the next step with a minimal intervention of a teacher. Therefore, the quality of self-regulated learning can be facilitated with a minimum of external regulation. In spite of possible connotations of the term "script",

the interface merely suggests learners to construct specific arguments by providing prompts learners should use or respond to (Baker & Lund, 1997; Dillenbourg, 2002; Kollar, Fischer, & Hesse, 2003; Nussbaum, Hartley, Sinatra, Reynolds, & Bendixen, 2002; Weinberger, 2003; Weinberger, Ertl, Fischer, & Mandl, 2005). In this approach, interfaces may be designed to specify and sequence and eventually to allocate different learning activities to learners. Studies show, that computer-supported collaboration scripts may support specific processes and outcomes of argumentative knowledge construction, but may have “side effects” on others (Dillenbourg, 2002; Weinberger et al., 2005). Kollar and colleagues (2003) investigated computer-supported collaboration scripts, which provide text spaces for claims and evidence that learners are supposed to fill as well as a specific sequence of arguments, counterarguments and integrations. Whereas learners acquired domain-specific knowledge independent of the script support in this study, computer-supported collaboration scripts facilitated knowledge on argumentation as an outcome of argumentative knowledge construction. Against this background, scripts can be conceptualized that facilitate the construction of a single argument according to Toulmin’s model (1958) and scripts that facilitate the construction of argumentation sequences according to Leitão (2000). A script for the construction of single arguments should facilitate the relative frequency of grounds that support a claim while a script for the construction of argumentation sequences should foster the relative frequency of counterarguments. Both scripts should support learners to apply concepts from prior knowledge to problems (application of prior knowledge) as well as the new theoretical concepts they are supposed to learn (application of new knowledge).

## RESEARCH QUESTIONS

There is little knowledge whether computer-supported collaboration scripts that specifically aim to support the construction of single arguments and argumentation sequences may foster the formal argumentative and / or the epistemic dimension of argumentative knowledge construction. Based on this, the following two research questions are examined:

- To what extent does a script for the construction of single arguments and a script for the construction of argumentation sequences and their combination, influence the processes of argumentative knowledge construction on the formal argumentative and the epistemic dimension?
- To what extent does a script for the construction of single arguments and a script for the construction of argumentation sequences and their combination, facilitate the outcomes of argumentative knowledge construction, namely domain-specific knowledge and knowledge on argumentation?

## METHOD

### Sample and Design

One hundred twenty students of educational psychology participated in this study. The experimental learning environment was part of a regular curriculum. The students, who were attending a mandatory introduction course, participated in an online learning session as a substitute for one regular face to face session of the course. Participation was required in order to receive a course credit at the end of the semester. The learning outcomes of the experimental session, however, were not accounted for in students’ overall performance. The participants were separated into groups of three and each group was randomly assigned to one of the four experimental conditions in a 2×2 factorial design. We varied (1) the script for the construction of single arguments (without vs. with) and (2) the script for the construction of argumentation sequences (without vs. with). Time on task was held constant in all four conditions.

### Learning environment in the different experimental conditions

The subject matter of the learning environment was Weiner’s attribution theory (1985). A three-page description of this theory was handed out to the students. Three learning cases were used as a central component of the learning environment. Each case was authentic and complex and allowed learners to construct different arguments based on theoretical concepts of the attribution theory. One case, for instance, asked to interpret school performance differences between Asian and American/European students with the attribution theory.

Three students worked together, but were placed separately in one of three different laboratory rooms. The group’s task was to analyze the three cases in an 80-minute collaboration phase and to provide a joint solution of the case. A problem-oriented learning environment, developed for asynchronous, text-based collaboration was used. The implemented newsgroup tool was used to exchange email-like text messages. In addition, the environment allowed for implementing different types of computer-supported collaboration scripts.

(1) The *control group* received no additional support in solving the three problem-cases.

(2) The *script for the construction of single arguments* is implemented in the interface as a given text structure within the individual messages and aims to support learners in the formation of single arguments. The script, based on Toulmin's model (1958), differentiates between claim, ground with warrant and qualifier and is realized by text windows in the interface of the CSCL environment (see figure 1). The learners were asked to fill out each text window of the interface to construct a complete single argument. After building the argument, the single argument would be added with a click to the message body. Non-argumentative parts of the message, like questions, could be added directly to the message body, without using the argument construction interface.

Figure 1. The interface of the script for the construction of single arguments.

(3) The *script for the construction of argumentation sequences* aimed to facilitate a specific argumentation sequence of argument-counterargument-integration (following Leitão, 2000). The subject of the posted message was automatically pre-set, depending on the position in the cascading discussion thread. Each first message of a discussion thread was labelled “argument”. The answer to an argument was automatically labelled as counterargument and a reply to a counterargument was labelled as integration. The next message was again labelled counterargument, then integration and so on. In this way, there was a default path through the discussion according to the Leitão model (see figure 2). The learners could change the subject of their message if necessary.

(4) In the *combined condition*, the learners are supported with both scripts during collaboration. The interface contains the three fields for argument construction and subjects of the messages are pre-set automatically by the script for the construction of argumentation sequences.



Figure 2. Discussion thread guided by the script for the construction of argumentation sequences.

## Procedure

First, pre-tests served to determine prior domain-specific knowledge, knowledge on argumentation and experience with CSCL environments. The pre-tests were used to control randomization. Subsequently, the participants were asked to study individually the three-page description of the attribution theory for 20 minutes. Learners were then introduced to the learning environment. Afterwards, the learners collaborated for 80 minutes in groups of three to work on the learning cases and to agree on case analyses. In the final phase (about 45 minutes), the students took individual post-tests on domain-specific application-oriented knowledge regarding the attribution theory and knowledge on argumentation tests.

## Data sources and instruments

Processes and outcomes of argumentative knowledge construction have been analyzed with an instrument described in Weinberger and Fischer (in press). Trained coders segmented the discourse corpora into propositions and rated the segments on the epistemic dimension with regard to application of prior knowledge and application of new knowledge and on the formal process dimension of argumentative knowledge construction with regard to the construction of single arguments and the construction of argumentation sequences. With respect to segmentation, the coders achieved an agreement of 83%. The median of the Kappa values for categorizing the epistemic dimension was sufficiently high with  $\kappa = .72$  as well as for the formal argumentative dimension ( $\kappa = .61$ ).

### Process variables

On the formal argumentative process dimension of argumentative knowledge construction, grounds as well as counterarguments have been coded. Grounds are reasons given in support of a claim. Grounds can come in form of facts, statistics, expert opinions, examples, explanations and logical reasoning. In the context of this study, learners may support claims with case information or concepts from the given attribution theory. Indicators for grounds that support claims are prepositions such as “because”, “due to the fact” etc. even though learners may not always explicitly connect grounds to the respective claims. For instance, if the claim, “Asian attribution patterns are typically superior” is based on the ground “Asians typically ascribe failure to a lack of efforts rather than a lack of talent”, this last phrase has been coded as one ground. The percentage of grounds has been calculated in comparison to other components of single arguments (simple claims, qualifiers, and non-argumentative moves such as questions). A high share of grounds indicates high-quality argumentative discourse with respect to the construction of single arguments.

Regarding the construction of argumentation sequences, the percentage of *counterarguments* was calculated in comparison to other argumentative moves within an argumentation sequence (arguments, integrations, and non-argumentative moves). Counterarguments are arguments that oppose another argument. The opposition of arguments has been assessed on the basis of differences of claims. If one claim contradicts a preceding claim, the later claim is being coded as counterargument. For instance, the argument “The teacher is supporting his pupils in adjusting the task difficulty to their individual skill levels” can be countered by the argument “The teacher is not supporting the pupils in adjusting the task difficulty (because adjusting task difficulty can be based on a dysfunctional attribution of the teacher)”. Counterarguments are typically expressed by another learner than the one who made the initial claim. Learners may, however, also construct counterarguments to their own arguments.

On the epistemic dimension, both the *application of new knowledge* and the *application of prior knowledge* have been focused on. With regard to the *application of new knowledge*, any unit of analysis has been coded that contains a relation of a theoretical concept from the given attribution theory to case information. For instance, the case information “Michael says he is not talented for maths” is explained with the following theoretical concept in the phrase “this indicates that Michael attributes his failure in maths to internal stable causes”. When learners explain case information with concepts that do not stem from the given attribution theory, they *apply prior knowledge* to case information, e.g., the case information “Michael says he is not talented for maths” is considered in “Michael is just plain lazy – he needs to acquire learning strategies and discipline”.

The processes on the formal argumentative and the epistemic dimension will be illustrated in a single case study based on a segment of a discussion thread that has been supported with the script for the construction of argumentation sequences. The segment will indicate the single messages, their titles, authors (with fictional names), and their position in the cascading discussion thread. Each message will be analyzed for the above process categories on the two dimensions, namely with regard to grounds, counterarguments, application of new knowledge and application of prior knowledge.

### Outcome variables

In order to measure *domain-specific knowledge*, participants had to individually analyze a new case. The written analyses of the participants were segmented into propositions and coded with respect to adequate applications of theoretical concepts of the attribution theory. The number of these propositions that the individual learners were able to construct was counted by five trained coders ( $\kappa = .72$ ) and served as indicator for the acquisition of domain-specific knowledge.

In the *knowledge on argumentation test* the participants had to recall components of single arguments and argumentation sequences. Furthermore, participants were asked to formulate arguments about “smoking” in the knowledge on argumentation test. The arguments that learners built were analyzed with respect to the components of single arguments (claim, ground, and qualifier). The argumentation sequences that learners built were analyzed with respect their function as argument, counterargument, and integration. Thus, *knowledge on the construction of single arguments* and *knowledge on the construction of argumentation sequences* were differentiated. Two trained coders rated the knowledge on argumentation test ( $\kappa = .83$ ).

## RESULTS

### Research Question 1 on processes of argumentative knowledge construction

First of all, the effects of the two computer-supported collaboration scripts and their combination on the processes of argumentative knowledge construction were examined. This includes the effects of the two scripts on the formal argumentative dimension and the effects of the scripts on the epistemic dimension.

With respect to the *formal argumentative dimension* the scripts produced the following specific effects on the relative frequency of *grounds* (see table 1 for percentage of grounds). The script for the construction of

single arguments increases the percentage of arguments based on grounds substantially and strongly ( $F_{(1, 36)} = 21.24$ ;  $p < .05$ ;  $\eta^2 = .37$ ). The script for the construction of argumentation sequences shows no effect on the percentage of grounds ( $F_{(1, 36)} = 0.02$ ; *n.s.*). No interaction effect of both scripts could be found ( $F_{(1, 36)} = 0.91$ ; *n.s.*).

Both scripts influenced the percentage of *counterarguments* (see table 1). The script for the construction of argumentation sequences strongly affected the percentage of counterarguments ( $F_{(1, 36)} = 9.08$ ;  $p < .05$ ;  $\eta^2 = .20$ ) positively, as did the script for the construction of single arguments ( $F_{(1, 36)} = 7.14$ ;  $p < .05$ ;  $\eta^2 = .17$ ). The two scripts did not interact with regard to the percentage of counterarguments ( $F_{(1, 36)} = 1.23$ ; *n.s.*).

Table 1. Formal argumentative dimension by experimental group: Mean percentages and standard deviations of grounds and counterarguments.

<i>Experimental group</i>	<i>Grounds</i>		<i>Counterarguments</i>	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Control group	12.08 %	11.48	2.46 %	3.67
Script for the construction of single arguments	33.80 %	11.19	5.36 %	8.07
Script for the construction of argumentation sequences	16.36 %	17.78	5.99 %	3.95
Combined condition	30.64 %	6.10	13.00 %	6.59

The computer-supported collaboration scripts also affected the *epistemic dimension* (see table 2). With regard to the *application of new knowledge*, the script for the construction of single arguments produced a negative effect ( $F_{(1, 36)} = 5.47$ ;  $p < .05$ ;  $\eta^2 = .13$ ). Neither a main effect of the script for the construction of argumentation sequences ( $F_{(1, 36)} = 1.91$ ; *n.s.*) nor an interaction effect of both scripts on application of new knowledge could be found ( $F_{(1, 36)} = 0.00$ ; *n.s.*).

The script for the construction of argumentation sequences significantly and strongly increases the *application of prior knowledge* ( $F_{(1, 36)} = 11.24$ ;  $p < .05$ ;  $\eta^2 = .24$ ). Neither a main effect of the script for the construction of single arguments ( $F_{(1, 36)} = 0.00$ ; *n.s.*) nor an interaction effect of both scripts could be found ( $F_{(1, 36)} = 0.90$ ; *n.s.*) with respect to application of prior knowledge.

Table 2. Epistemic dimension by experimental group: Means and standard deviations of application of new knowledge and application of prior knowledge.

<i>Experimental group</i>	<i>Application of new knowledge</i>		<i>Application of prior knowledge</i>	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Control group	7.97	3.45	13.80	7.93
Script for the construction of single arguments	5.07	3.75	16.80	8.52
Script for the construction of argumentation sequences	6.23	4.16	27.00	12.78
Combined condition	3.43	4.03	24.20	8.72

Both scripts successfully facilitated the specific processes of argumentative knowledge construction they aimed at. Supported with the script for the construction of single arguments, the percentage of grounds doubles, but still only one third of the claims is supported with grounds. Both scripts double the share of counterarguments, but typically learners do not construct counterarguments, but argue in favor of one claim only. Both scripts seem to have specific “side effects” on the epistemic dimension. Learners with the script for the construction of single arguments less frequently show applications of new knowledge and learners with the script for the construction of argumentation sequences show applications of prior knowledge more frequently than learners without scripts. In order to illustrate these effects on the epistemic and formal dimension of argumentative knowledge construction simultaneously, a discourse segment of a learning group supported by the script for the construction of argumentation sequences is presented next. This discourse segment has been selected to illustrate a discourse with a high frequency of application of prior knowledge.

The learning case that the learners work on in this example is about a pupil who is afraid not to make mathematics class next year, because he thinks he is not talented for this subject (internal stable self-attribution). His parents equally attribute their son’s failure on lack of talent (internal stable attribution of others), whereas his teacher ascribes his failures to a lack of efforts (internal variable attribution of others). In the learning group

of three, 32 messages in two threads have been sent to discuss and analyze this case. This means that two “argumentation” messages have been followed by 17 messages automatically labeled “counterargument” and 13 messages automatically labeled “integration”. The participants did not replace or modify any of the automatically set subjects of the messages. Eight messages from one of the discussion threads have been selected for the example illustration.

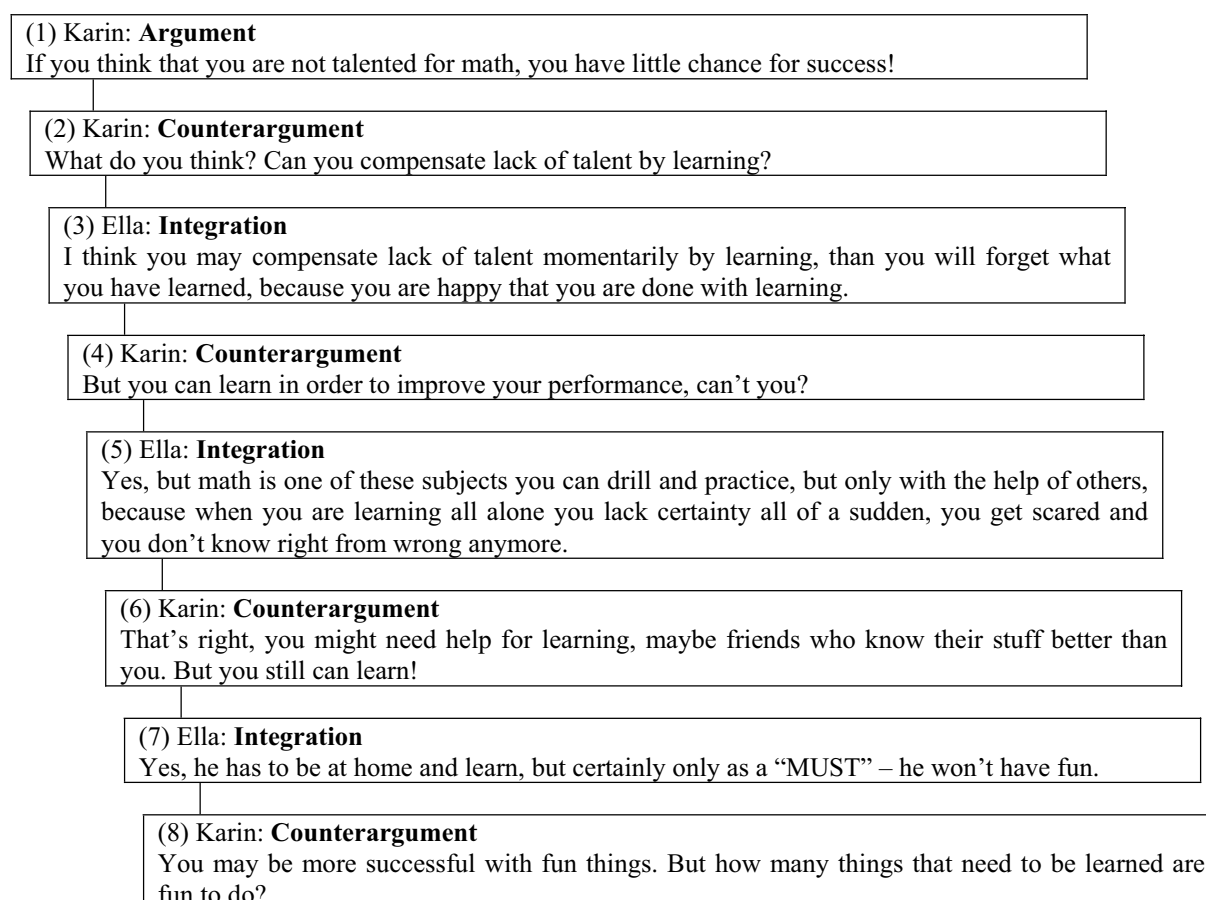


Figure 3. Schematic representation of a segment of one of the discussion threads from an example discourse that has been supported by the script for the construction of argumentation sequences.

In this example (see figure 3), the first message (1) of Karin labeled “Argument” is a short explanation of the learning case which can be categorized as application of new knowledge, because the attribution theory states that the attribution for failure on lack of talent decreases chances for success. Ignoring the label “Counterargument”, the same learning partner, Karin, continues the discussion thread and (2) replies to herself with a message containing questions that point beyond analyzing the case with the attribution theory. Karin’s learning partner, Ella, (3) replies to that in a message labeled “Integration” and constructs a claim that is supported by a ground, but shows application of prior knowledge rather than analyzing the case with adequate concepts from attribution theory. Karin (4) replies with a message labeled “Counterargument”. Her message actually contains a counterargument (without grounds and qualifiers) to Ella’s claim that learning compensates lack of talent only momentarily, but Karin does not return to analyze the case with new knowledge, but rather discusses other aspects of the learning case and applies prior knowledge. Another (5) message labeled “Integration” from Ella follows. However, this message is actually rather a counterargument than an integration. On the epistemic dimension, Ella does not apply new knowledge, but yet again introduces new aspects (application of prior knowledge), namely instructional approaches towards the subject mathematics. Karin’s (6) message “Counterargument” again actually contains a counterargument. On the epistemic dimension, she also applies prior knowledge. Ella then (7) turns to other motivational approaches (application of prior knowledge) to make her point that learning is of little help in this case, but again does not refer to the theory which is to be learned. Her “Integration” message can be coded as counterargument. Karin finally (8) notes that motivation is important for learning, but not sufficient to explain performance differences in different subjects (application of prior knowledge). In opposing Ella, Karin constructs a counterargument.

First of all, it can be noted that learners apply an argument-counterargument sequence. The learners do not always respond to the given labels of their messages in the intended manner, e.g., they construct a

counterargument even if their message has been automatically labeled “integration”. Learners do not always follow the prescriptions of the script for the construction of argumentation sequences. But as the results show, the computer-supported collaboration scripts still affect the processes of argumentative knowledge construction in the intended direction.

With regard to the formal argumentative dimension, Ella claims that learning may not improve performance, which she supports with various grounds (messages 3, 5, and 7). Karin constructs the counterargument that learning may improve performance (messages 4, 6, and 8). With regard to the epistemic dimension, the participants appear to wander off the actual task to analyze the case with the help of concepts from attribution theory (application of new knowledge). Instead, learners apply prior knowledge starting with the second message of this discussion thread. Karin is asking the question which leads learners to discuss their epistemological beliefs on the efficacy of learning.

## Research Question 2 on outcomes of argumentative knowledge construction

In order to answer research question 2, the influence of the two computer-supported collaboration scripts on the *outcomes* of argumentative knowledge construction, namely domain-specific knowledge and knowledge on argumentation was examined.

Neither the script for the construction of single arguments ( $F_{(1, 36)} = 0.33$ ; *n.s.*), nor the script for the construction of argumentation sequences ( $F_{(1, 36)} = 0.08$ ; *n.s.*), nor the interaction of both scripts ( $F_{(1, 36)} = 1.27$ ; *n.s.*) facilitated the acquisition of domain-specific knowledge. Learners of all four experimental conditions did not differ with respect to the acquisition of domain-specific knowledge.

*Knowledge on argumentation* could be specifically facilitated with the scripts.

Table 4. Outcomes of argumentative knowledge construction by experimental group: Means and standard deviations of domain-specific knowledge and knowledge on argumentation.

Experimental group	Domain-specific knowledge		Knowledge on the construction of			
	<i>M</i>	<i>SD</i>	single arguments		argumentation sequences	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Control group	4.33	2.16	3.08	1.08	2.23	1.65
Script for the construction of single arguments	4.70	1.49	4.17	1.55	2.03	1.69
Script for the construction of argumentation sequences	4.90	2.52	2.70	1.21	5.25	1.05
Combined condition	3.77	2.12	4.78	0.75	4.55	0.85

The script for the construction of single arguments strongly facilitated *knowledge on the construction of single arguments* ( $F_{(1, 36)} = 17.97$ ;  $p < .05$ ;  $\eta^2 = .33$ ), whereas no effect of the script for construction of argumentation sequences ( $F_{(1, 36)} = 0.10$ ; *n.s.*) nor an interaction effect of both scripts could be found ( $F_{(1, 36)} = 1.79$ ; *n.s.*).

The script for the construction of argumentation sequences strongly facilitated *knowledge on the construction of argumentation sequences* ( $F_{(1, 36)} = 41.50$ ;  $p < .05$ ;  $\eta^2 = .54$ ), whereas no effect of the script for the construction of single arguments ( $F_{(1, 36)} = 1.10$ ; *n.s.*) nor an interaction effect of both scripts could be found ( $F_{(1, 36)} = 0.39$ ; *n.s.*).

Although all experimental groups acquired a similar amount of domain-specific knowledge, both scripts successfully facilitated the acquisition of knowledge on the construction of single arguments or the construction of argumentation sequences. The learners were able to construct single arguments and argument sequences depending on what the computer-supported collaboration script aimed at. The scripts did not interact and can be combined to foster knowledge on the construction of single arguments as well as knowledge on the construction of argumentation sequences at the same time.

## CONCLUSIONS

Computer-supported collaborative learning can be realized in the curriculum of university studies and facilitated with computer-supported collaboration scripts. Compared to traditional classroom settings, students can thus be encouraged to actively construct arguments (cf. Cohen & Lotan, 1995; Weinberger, 2003). Potential settings for CSCL in university lectures could be that learners build small groups and work on problems together via the internet. Computer-supported collaboration scripts can facilitate specific processes and outcomes of argumentative knowledge construction of students in higher education. The analysis of the formal argumentative



dimension of the discourse within the learning groups of the control condition showed in line with other studies (Kuhn, 1991; Kuhn et al., 1997), that learners hardly base their claims on grounds and hardly construct counterarguments. The computer-supported collaboration scripts showed that they can improve the argumentative discourse quality of students. Scripts could be integrated into a CSCL environment and proved to facilitate the percentage of grounds and counterarguments that learners construct in argumentative discourse. Thus, the scripts improved the formal argumentative dimension and influenced the epistemic dimension of argumentative knowledge construction. Learners with the script for the construction of single arguments did not as frequently engage in the application of new knowledge as learners without the script. The script for the construction of argumentation sequences facilitated the application of prior knowledge. Computer-supported collaboration scripts may activate prior knowledge and facilitate learners to come up with alternative explanations. An explanation for the pattern of results with respect to the processes of argumentative knowledge construction is that the scripts provided a structure that defined the activities of the learners with respect to the formal argumentative dimension, but shifted the focus of learners away from the question with what kind of content this structure is supposed to be filled. Thus, learners may have been more concerned to satisfy the affordances on the formal argumentative dimension than on the epistemic dimension. Learners were challenged to find grounds and counterarguments, but not supported with respect to the question on what contents these grounds and counterarguments should be based on. Therefore, the prior knowledge may have been more easily available to learners to apply than the new knowledge concepts that were to be learned.

In line with other studies (e.g., Kollar et al., 2003), the scripts facilitated knowledge on argumentation on the specific levels they were aiming at, but did not facilitate domain-specific knowledge. Assumptions that the construction of arguments also leads to the acquisition of domain-specific knowledge through elaboration of the learning material cannot be fortified (Baker, 2003). An explanation for this is that learners supported with the scripts focused on the construction of arguments, but may have based their arguments rarely on new knowledge, which has been found to be related to acquisition of domain-specific knowledge (Weinberger, 2003). It can be assumed that parts of these results can be traced back to the specific effects of the scripts on the processes of argumentative knowledge construction. Therefore, future scripts might need to foster both the formal argumentative and the epistemic dimension of argumentative knowledge construction in order to facilitate students to learn to argue on a general level as well as within their domain. There are indications, however, that knowledge on argumentation may foster acquisition of domain-specific knowledge in the long run (see EUROSCALE project at <http://www.euroscale.net>; Kollar et al., 2003). In reference to this prior work, the scripts applied in this study may be an apt instructional method to foster knowledge on argumentation in CSCL environments and future argumentative knowledge construction scenarios.

Knowledge on argumentation is important for lifelong learning and should be further developed (Andriessen et al., 2003; Linn & Slotta, 2000). Based on this study, consequences for practitioners as well as researchers can be drawn. In the educational practice of universities, specific scripts in problem-oriented environments may endorse argumentation trainings. Scripts for argumentative knowledge construction can activate prior knowledge of learners and facilitate acquisition of argumentative knowledge without impeding acquisition of domain-specific knowledge. The study has also shown that CSCL environments could endorse university curricula and thus change educational practice. Teachers or coaches can integrate computer-supported scripts into ongoing collaboration processes with little additional effort. With regard to future CSCL research, there is a lack of studies on computer-supported collaboration scripts in field settings like classrooms or university lectures in different domains. Additionally, we need to further investigate the combination of script components with different goal dimensions, e.g., scripts that also facilitate the epistemic dimension of argumentative knowledge construction (Weinberger et al., 2005). We therefore suggest systematizing the effects of computer-supported collaboration scripts in universities. An important step in making scripts available and applicable in different university departments is to formalise script components that aim at specific aspects of argumentative knowledge construction. Computer-supported collaboration scripts may thus support specific forms of argumentative discourse within different domains and CSCL may become an endorsement to argumentative knowledge construction in higher education.

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