Scripting argumentative knowledge construction in computer-supported learning environments

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SCRIPTING ARGUMENTATIVE KNOWLEDGE CONSTRUCTION IN COMPUTER-SUPPORTED LEARNING ENVIRONMENTS

Abstract. Argumentative knowledge construction in computer-supported collaborative learning environments is often weak. This experimental study analyzes two collaboration scripts, which should facilitate argumentative knowledge construction. One script aims to support the construction of argumentation sequences and the other script aims to support the argument construction. These scripts should facilitate the argumentative knowledge construction on both the micro- and macrostructure of argumentation during process as well as with respect to the individual outcome. Both types of scripts were varied independently in a 2X2-factorial design. 120 students of Educational Science participated in the study in groups of three. Results show that discourse supported by the collaboration scripts was of higher quality and students in these conditions acquired more individual knowledge about argumentation than learners without cooperation scripts.

1. OBJECTIVES

A central task of education is seen in preparing students for lifelong learning. The competencies of argumentation are an important part of this because these competencies are necessary for both to understand and participate in discourse. Moreover, recent approaches in instruction link argumentation with the collaborative knowledge construction (see Fischer, 2002). From this perspective, argumentation is no longer only the goal per se, but also a tool for knowledge acquisition. As an important condition of the development of this competencies, we regard the active participation in high-quality, argumentative discourse in formal instructional settings (Kuhn, 1991). During collaboration, arguments are exchanged and cooperation partners examine and evaluate these arguments. However, studies showed that argumentative quality in discourse is often weak.

The goal of this study is to facilitate both, process and outcome of argumentative knowledge construction by means of a computer-supported collaborative learning environment with integrated cooperation scripts.

2. THEORETICAL FRAMEWORK

2.1. Processes of argumentative knowledge construction

In recent years approaches for promoting argumentative competencies in learning groups have been examined. Argumentative skills are not only a prerequisite of collaborative knowledge construction but also a learning goal during collaboration. In this study the competence level of argumentation is analyzed on a micro- and macrostructure:

According to Toulmin (1958; Toulmin, Rieke, & Janik, 1984) an individual argument consists of a statement which can be supported by a warrant and/or

specified by a quantifier (*microstructure*). The warrant contains a justification for the statement. The quantifier limits the validity of the statement and can be represented optionally and sometimes implicitly in the structure of an argument, e.g. indicated by the word "perhaps". As an indicator for high argumentative competence with respect to the microstructure we regard the frequent use of warrants and quantifiers in an argument. The *macrostructure* is directed toward the argumentation sequence examining how discussion participants in discourse, create an argumentation pattern together. The analysis typically focuses on the rhetorical function of individual expressions in a sequence of contributions. Central concepts are argument, counterargument and reply/integration (e.g., Leitão, 2000). As an indicator for high argumentative competence with respect to the macrostructure we regard the well-adjusted use of arguments and counterarguments and moreover the formulation of integrations of several arguments. Whereas single arguments can be evaluated with regard to microstructure, macrostructure describes the dynamics of the argumentation processes (see Leitão, 2000). Following these concepts, a high quality argumentative discourse should contain an equally high argumentative level, e.g., the cooperation partners should have convergence in argumentative knowledge construction. Only when all participants build equally good arguments, can the collaboration be successful.

Beyond formal aspects of argumentative quality, the epistemic quality of the argumentation play a crucial roles (Kuhn, Shaw, & Felton, 1997). For high learning outcome it seems important, that discourse in collaboration is of high epistemic quality and task-oriented (Gräsel, Fischer, Bruhn, & Mandl, 2001). In addition, learners may or may not converge with their learning partners. Epistemic process convergence means that learners use the same knowledge concepts during communication (Fischer & Mandl, 2001).

2.2. Computer-supported cooperation scripts to facilitate argumentation

Different choices are possible to foster acquisition of (argumentative) competencies, e.g., trainings or instructional support through cooperation scripts. Whereas trainings are connected with large effort in the forefront of cooperation, computer-supported collaboration scripts can be integrated in the communication-interface. Cooperation-scripts are instructions, which specify and sequence learning activities. When needed, these scripts allocate different activities to several learners.

The results of different studies show (Hron, Hesse, Reinhard, & Picard, 1997; Weinberger, Fischer, & Mandl, 2003), that cooperation-scripts posses the potential to support argumentative knowledge construction. Regarding these studies, computer-based argumentative cooperation-scripts should be able to positively influence the quality of argumentative knowledge construction. For optimal support both the micro- and the macrostructure of argumentation need a special cooperation script. A script for the microstructure should foster warrants and quantifier of an argument while a script for the macrostructure should foster the well-adjusted use of arguments and counterarguments as well as the use of integrations. In addition, the

use of argumentative scripts should foster both learning outcome and knowledge about argumentation.

Based on this, the following two research questions are examined:

- To what extent does a script for the construction of argumentation sequences and a script for argument construction and their combination, influence the process of argumentative knowledge construction?
- To what extent does a script for the construction of argumentation sequences and a script for argument construction and their combination, influence the outcome of argumentative knowledge construction?

3. METHOD

3.1. Sample and Design

One hundred twenty students of educational psychology volunteered in this study. The experimental learning environment was part of a regular curriculum. 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 (see table 1). We varied (1) the script for the construction of argumentation sequences (without vs. with) and (2) the script for argument construction (without vs. with). Time-on-task was held consistent in all four conditions.

Table 1. Experimental design of the study with number of participants and number of groups in brackets of each setting.

		Script for the argument construction	
		Without	*With*
Script for the construction of argumentation sequences	*Without*	30 (10)	30 (10)
	With	30 (10)	30 (10)

3.2. Learning environment in the different experimental conditions

The subject matter of the learning environment was Weiner's attribution theory (1985). A three-page summary of this theory was made available for students. Three learning cases were used as a central component of the learning environment. Each case was authentic and complex and allowed learners to use the theoretical concepts of the attribution theory.

Three students worked separately in one of three different laboratory rooms. The learners' task was to analyse together the three cases in an 80-minute cooperation phase and to provide a common case solution. A problem-oriented learning environment, developed for asynchronies, text-based collaboration was used. The

implemented newsgroup tool was used to exchange email-like text messages. In addition, the environment allows for implementing different types of cooperation scripts.

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

(2) The *script for the construction of argumentation sequences* was based on the macrostructure of argumentation (following Leitão, 2000). The subject of the posted message was automatically pre-set, depending on the position in discourse. If necessary, the learners could change completely the subject of their message. The answer to an argumentation was automatically labelled as counter-argumentation and an answer to a counter-argumentation was labelled as integration.

(3) The *script for argument construction* is implemented as a given text structure within the individual messages and aims to support learners in the formation of several arguments. The script for argument construction, based on Toulmin's model (1958), differentiates between statement, date, warranty and quantifier. The interface (see figure 1) contained fields for statements, warrants and restrictions/premises. The learners where asked to fill out the argument construction interface completely to construct for each single argument. After building the argument, the single argument would be added with a click to the message body. Meta-argumentative parts of the message, like questions, could be added directly to the message body, without using the argument construction interface.

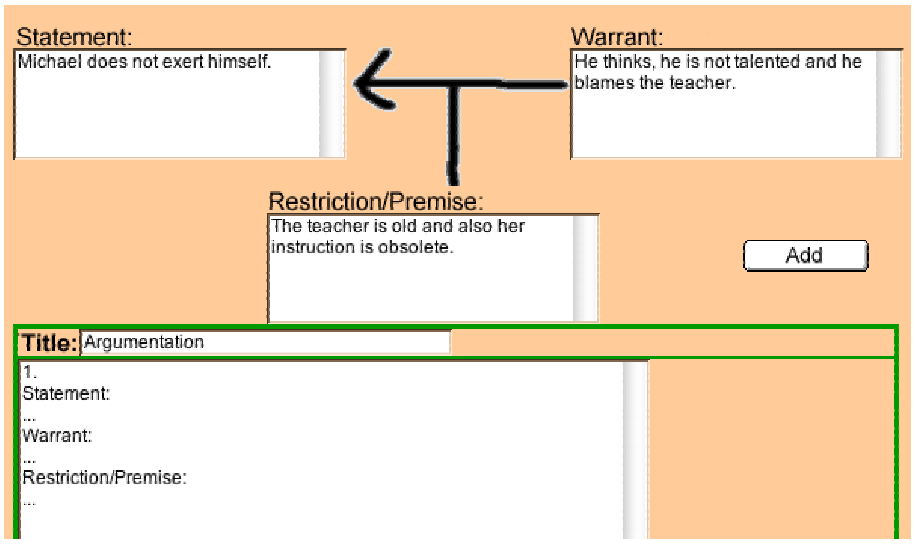

Figure 1. The interface of the script for argument construction.

(4) In the *combined condition* the learners are supported during their case processing with both scripts. The interface contains the three fields for argument construction and subjects of the messages will be automatically pre-set.

3.3. Procedure

During the first phase pre-tests were given, which served to determined prior knowledge and experience and were used to control randomization. Subsequently, the participants had 20 minutes time to study the three-page theory summary individually. Learners were then introduced to the learning environment. After an introduction with respect the learning environment, the learners began the 80-minute collaboration phase. In groups of three they worked on problem cases and were asked to agree on case analyses. In the final phase (about 45 minutes), the students took post-tests on knowledge regarding the treated theory and argumentation knowledge.

3.4. Data sources and instruments

Trained coders rated the common (discourse) and individual (post-test) case processing. The texts were segmented into propositions. The content was then rated by attribution theory and micro- and macrostructure of argumentation. The coders achieved, with respect to the segments, a proportional agreement of 83%. The median of the Kappa values was sufficiently high.

3.4.1 Process variables

According to expert analyses, twenty-seven different correct propositions between theory and case information in discourse, with respect to Weiner's attribution theory, were identified. The amount of different correct propositions was used as *epistemic quality of the process of argumentative knowledge construction* in discourse. According to process quality, the *qualitative epistemic process convergence* was defined as knowledge similarity in individual transfer. The convergence between learning partners was calculated regarding the proposition in the messages within one and the same learning group.

In this study both, the *quality of micro- and the macrostructure of the argumentation* (Leitão, 2000; Toulmin, 1958) in the process of argumentative knowledge construction were rated. On the microstructure, statements without or with warrant, statements without or with quantifier and their combination were differentiated. The following portions of statements were calculated: (1) *without warrant - without quantifier*, (2) *without warrant - with quantifier*, (3) *with warrant - without quantifier*, (4) *with warrant - with quantifier*. On the macrostructure, between (5) *arguments*, (6) *counterarguments* and (7) *consequences* (integrations) were differentiated and portions were calculated. To compute *quantitative argumentative process convergence* of these seven argumentative dependent variables the portion of standard deviation of mean was calculated, e.g. a mean of 2 and standard deviation of .25 leads to a convergence portion of 12.5%.

3.4.2 Outcome variables

Similar to epistemic process quality, *outcome of argumentative knowledge construction* was defined. Corresponding to expert analyses, thirty-four different correct propositions were identified. According to the outcome, the *qualitative outcome convergence* was defined as knowledge similarity and calculated like qualitative epistemic process convergence.

In the *argumentative knowledge test* the subjects both, designate components (complete argument and complete argumentation sequence) and formulate examples about "smoking". The *knowledge about argumentation regarding microstructure* and the *knowledge about argumentation regarding the macrostructure* were differentiated. Two trained coders rated the argumentative competencies test. The Kappa-value was .83.

4. RESULTS

4.1. Research Question 1

First, the influence of the two collaboration scripts and their combination on the process of argumentative knowledge construction was examined.

The *epistemic quality of the discourse* is negatively affected by the argument construction script ($F(1)=6.21$; $p<.05$; strong effect). All groups supported by the script for argument construction formulated obvious, more correct inferences, less often than the groups without this script. The argument construction script had also a negative effect ($F(1)=4.03$; $p<.05$; middle effect) on the *qualitative epistemic process convergence*.

The *quality of the argument microstructure* is substantially and strongly affected by the argument construction script ($F(1)=44,70$; $p<.001$;). A reduction in statements *without warrant – without quantifier* can be seen in relation between the control condition without this script ($M=66.60\%$; $SD=18.54$) and the condition with the script for argument construction ($M=37.99\%$; $SD=12.95$). In contrast to the statements *without warrant – without quantifier*, the proportion of the statements *with warrant - without quantifier* lies at $M=32.86\%$ ($SD=15.29$) approximately 16% over the proportion of subjects without the script for argument construction. Also the percent of the statements *without warrant - with quantifier* lays 16% above the subjects of the control group ($M=3.61\%$; $SD=5.95$).

Table 2. Mean percentages and standard deviations of statements without warrant and without quantifier by experimental groups.

Experimental group	*M*	*SD*
Control group	66.60%	18.54
Script for the construction of argumentation sequences	68.71%	23.52
Script for the argument construction	37.99%	12.95
Combined condition	53.32%	15.06

The *quality of the argument macrostructure* is affected both by the argument construction script ($F(1)=4.82$; $p<.05$; middle effect) and by the script for the construction of argumentation sequences ($F(1)=7.52$; $p<.01$). The group supported by the script for argument construction formulated more *counterarguments* than the control group. The group supported by the script for the construction of argumentation sequences formulated more *counterarguments* than the control group.

The argument construction script however, had a negative effect on the proportion of *consequences* ($F(1)=6.31$; $p<.05$; middle effect). In comparison to the control group, fewer consequences were formulated.

The *quantitative argumentative process convergence* with respect to the *argument microstructure* is substantially and strongly affected by the argument construction script ($F(1)=8.42$; $p<.001$). A reduction of divergence in statements *with warrant – without quantifier* can be seen in relation between the control condition without this script ($M=133.27\%$; $SD=53.29$) and the condition with the script for argument construction ($M=85.81\%$; $SD=13.16$).

The *quantitative argumentative process convergence* with respect to the *argument macrostructure* is affected by the argument construction script with respect to *counterarguments* ($F(1)=26.76$;$p<.001$; strong effect; see table 3) and with respect to *consequences* ($F(1)=8.42$; $p<.01$; strong effect). With respect to formulated *counterarguments*, the group supported by the script for argument construction ($M=72.46\%$; $SD=36.30$) is clearly less divergent than the control group ($M=148.90\%$; $SD=36.51$) or the condition with the script for argument construction ($M=137.92\%$; $SD=60.86$). With respect to formulated *consequences*, the group supported by the script for argument construction ($M=85.81\%$; $SD=13.16$) is clearly less divergent than both control group ($M=133.27\%$; $SD=53.29$) or condition with the script for argument construction ($M=101.35\%$; $SD=46.33$). No interaction effect was found.

Table 3. Mean percentages and standard deviations of process convergence with respect to formulated counterarguments by experimental groups.

Experimental group	*M*	*SD*
Control group	148.90%	36.51
Script for the construction of argumentation sequences	72.46%	36.30
Script for the argument construction	137.93%	60.86
Combined condition	67.15%	34.10

4.2. Research Question 2

The influence of the two collaboration scripts on the *outcome* of argumentative knowledge construction was examined.

No effects of argumentative collaboration scripts on *outcome of argumentative knowledge construction* were found. However, there was an obvious facilitation of knowledge about attribution theory in all four groups (M=13.25; SD=6.19). The highest amount of correct propositions was found in the setting with the script for the construction of argumentation sequences (M=16.00; SD=7.87), while the lowest learning outcome occurred in the combined setting (M=11.00; SD=5.89). The control group (M=12.60; SD=6.02) and the group supported by the argument construction script (M=13.40; SD=4.33) had a very similar learning outcome.

The *qualitative outcome convergence* is negatively affected by the argument construction script ($F(1)=4.45$; $p<.05$). This script decreases the convergence in knowledge about the attribution theory.

Table 4. Means and standard deviations of knowledge regarding macrostructure of argumentation by experimental groups.

Experimental group	*M*	*SD*
Control group	2.27	2.12
Script for the construction of argumentation sequences	5.27	1.48
Script for the argument construction	1.90	1.95
Combined condition	4.50	2.30

The *knowledge about argumentation regarding microstructure* were affected strongly and substantially by the argument construction script ($F(1)=59.58$; $p<.001$). The subjects supported by this script knew M=4.38 (SD=2.06) components of an argument, whereas the control group knew only M=3.03 (SD=1.43) components.

The script for the construction of argumentation sequences substantially and strongly affected *knowledge about argumentation regarding macrostructure*

($F(1)=235.20$; $p<.001$; see table 4). The control group knew on average $M=2.27$ ($SD=2.12$) macrostructure components. The subjects supported with the argument construction script knew $M=5.27$ ($SD=1.48$) macrostructure components.

Both scripts successfully facilitated the acquisition of argumentative competencies, in each case on the intended level. The learners were able to list components of arguments and argument sequences and could construct example arguments and argument sequences. They acquired argumentative competencies.

5. CONCLUSIONS

Argumentation is an important competency in computer-supported collaboration. But our results show that to set up collaboration is not enough to foster it. The analysis of the micro- and macrostructure of the discourse within the learning groups of the control condition showed, like other studies before (Kuhn, 1991; Kuhn et al., 1997), that the quality of the argumentative knowledge construction without suitable support is insufficient. Approximately 83% of the statements during discourse were not justified. The script for argument construction proved to be very successful in this context. The script for construction of argumentation sequences however, had only a small influence on the macrostructure. Counterarguments and integrations were very rare, also with support of the scripts. The sum of the counterarguments and the integrations made up less than 14% of the discourse.

In addition, the individual acquisition of knowledge about argumentation is also low in the control group. However, our outcomes show that the argumentative competencies can be enhanced in online learning environments in a very direct way. Furthermore, during discourse the script for argument construction resulted in higher argumentative quality, but also reduced the epistemic quality. It seems that the argument construction script leads to more complete arguments on one hand. On the other hand some of these arguments were built with irrelevant information. Future argumentative cooperation scripts should foster both the argumentative and epistemic quality.

This study also showed that argumentative collaboration scripts are able to foster argumentative competencies because they are able to support both, argumentative knowledge construction during discourse and the acquisition of individual knowledge about argumentation. The scripts promote specifically the individual knowledge acquisition regarding argumentation. The script for argument construction promotes knowledge about the microstructure of arguments and the script for construction of argumentation sequences promotes knowledge about the macrostructure of argumentation.

In line with other studies (Weinberger, Fischer, & Mandl, 2001; Weinberger et al., 2003) these outcomes show once more, that cooperation scripts are able to affect collaborative learning in different ways. Scripts may aim at different aspects of argumentative knowledge construction and provide detailed support on a microlevel or aim at macrolevels of argumentative knowledge construction. Therefore, a classification or formalisation of cooperation scripts is needed. This would help to

evaluate, compare and combine different cooperation scripts. In addition, such a formalisation could be used as guideline to develop new cooperation scripts.

Argumentative knowledge construction is an important skill for lifelong learning and should be further developed (Linn & Slotta, 2000). Argumentative collaboration scripts in problem-oriented environments may endorse argumentation trainings. Teachers or coaches can integrate argumentative collaboration scripts into ongoing collaboration processes with little additional effort. Up until now, there is a lack of systematic research on computer-supported cooperation scripts in field settings like classrooms or university lectures. Furthermore, effects of computer-supported scripts on argumentative knowledge construction in other domains must be examined.

AFFILIATIONS

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