OPEN ACCESS
OPUS AUGSBURG

Universität Augsburg
Universitätsbibliothek

Fostering argumentation skills in mathematics with adaptable collaboration scripts: only viable for good self-regulators?

Freydis Vogel, Ingo Kollar, Stefan Ufer, Elisabeth Reichersdorfer, Kristina Reiss, Frank Fischer

Angaben zur Veröffentlichung / Publication details:

Vogel, Freydis, Ingo Kollar, Stefan Ufer, Elisabeth Reichersdorfer, Kristina Reiss, and Frank Fischer. 2015. "Fostering argumentation skills in mathematics with adaptable collaboration scripts: only viable for good self-regulators?" In *Exploring the material conditions of learning: 11th International Conference on Computer Supported Collaborative Learning (CSCL 2015), Gothenburg, Sweden, June 7-11, 2015*, edited by O. Lindwall, P. Häkkinen, T. Koschmann, P. Tchounikine, and S. Ludvigsen, 576–80. Gothenburg: International Society of the Learning Sciences.

Nutzungsbedingungen / Terms of use: **licgercopyright**

Dieses Dokument wird unter folgenden Bedingungen zur Verfügung gestellt: / This document is made available under these conditions:
Deutsches Urheberrecht
Weitere Informationen finden Sie unter: / For more information see:
https://www.uni-augsburg.de/de/organisation/bibliothek/publizieren-zitieren-archivieren/publiz/

Fostering Argumentation Skills in Mathematics with Adaptable Collaboration Scripts: Only Viable for Good Self-Regulators?

Freydis Vogel, Technical University Munich, freydis.vogel@tum.de
Ingo Kollar, Ludwig-Maximilians-Universität Munich, ingo.kollar@psy.lmu.de
Stefan Ufer, Ludwig-Maximilians-Universität Munich, ufer@math.lmu.de
Elisabeth Reichersdorfer, Technical University Munich, elisabeth.reichersdorfer@tum.de
Kristina Reiss, Technical University Munich, kristina.reiss@tum.de
Frank Fischer, Ludwig-Maximilians-Universität Munich, frank.fischer@psy.lmu.de

Abstract: Argumentation scripts have been proposed as an effective means to structure students' argumentation and to support their acquisition of argumentation skills. Yet, argumentation scripts run the danger of overscripting students' argumentation. A possible solution might be to offer adaptable argumentation scripts that allow students to adjust the script to their own needs. This study compares the effects of three argumentation scripts (high structured vs. low structured vs. adaptable) on students' argumentation skills. Furthermore, we investigate to what extent students' self-regulation skills influence the acquisition of argumentation skills in the three conditions. N = 109 math students were randomized to the three treatment conditions and worked in dyads on mathematical proof tasks in a CSCL environment. Students' argumentation skills increased between pre- and post-tests with comparable gains in all three conditions. Only for students learning with the adaptable argumentation script, self-regulation skills were a significant positive predictor for argumentation skills.

Keywords: collaboration scripts, argumentation, mathematics.

Introduction

To be able to engage in high-level argumentation has often been described as an important precondition to gain knowledge in a given domain ("arguing to learn"; Andriessen, Baker & Suthers, 2003). When situated in a social context, argumentation includes the production and exchange of well-warranted arguments and counterarguments and possibly the construction of a synthesis of different arguments that were previously expressed by different learners (see Leitão, 2000). Even in rather well-structured domains such as mathematics, in which often more systematic instructional methods are suggested (such as worked examples; Atkinson, Derry, Renkl & Wortham, 2000), the potential of putting learners in social contexts in which they engage in collaborative argumentation for knowledge construction has been recognized (e.g., Kollar, et al., 2014; Zemel & Koschmann, 2013).

Nevertheless, by far not all learners are able to engage in high-level argumentation spontaneously (Stegmann, Weinberger, & Fischer, 2007). Particular kinds of scaffolding that can be designed to help students engage in high-level argumentation are argumentation-related collaboration scripts ("argumentation scripts" hereafter). Mostly studied in domains other than mathematics, argumentation scripts structure collaboration by specifiying, sequencing and distributing high-level argumentation activities among the learners of a small group (Kollar, Fischer & Hesse, 2006). For instance, while one learner may be prompted to make a claim and provide evidence for it, his/her learning partner may be asked to provide counterevidence. Empirically, such argumentation scripts have been shown to be effective for the development of students' argumentation skills (e.g. Noroozi, Weinberger, Biemans, Mulder, & Chizari, 2013).

Yet, collaboration scripts have in the past been criticized with respect to the high rigidity by which they structure the collaborative learning process. More specifically, scripting argumentation often comes with a restriction of learners' autonomy to apply their own – possibly functional – learning strategies and thus may not always lead to optimal learning outcomes ("over-scripting", Dillenbourg, 2002). As a reaction to this criticism, attempts have been undertaken to design more flexible collaboration scripts by making them adaptive. Often based on intelligent tutoring technology, adaptive scripts continuously assess the quality of the collaborative learning process and fade parts of the collaboration script in or out as needed (Diziol, Walker, Rummel & Koedinger, 2010). An alternative to the often costly development of intelligent tutoring technologies that enable such a continuous assessment of learning processes might however be to make collaboration scripts adaptable, i.e. to grant learners themselves the opportunity to switch parts of the script on and off, based on their self-perceived needs. On the one hand, adaptable scripts offer a valuable opportunity for self-regulated learning, as

decisions on how to adapt the script must be made on a thorough analysis of the previous learning episode and an estimation of one's own competence level (Järvelä & Hadwin, 2013). On the other hand, unfortunately, learners who are not able to self-regulate their learning effectively may make wrong decisions when granted the opportunity to adapt their script and thus not benefit from the opportunities offered by adaptable scripts.

Research questions and hypotheses

Overall, this paper addresses two research questions:

RQ 1: To what extent do the structure and the adaptability of an argumentation script (low structured script vs. high structured script vs. adaptable script) affect the learners' acquisition of argumentation skills?

We hypothesized that learners presented with a high structured argumentation script would outperform students from the low structured script condition. Learners from the adaptable script condition should on average reach higher levels than students from the low structured script condition because students from the adaptable script condition have at least the chance to choose a high-structured collaboration script to be displayed to them. With regard to the comparison between students from the high structured and the adaptable script condition, we did not set up a directed hypothesis, as one may either expect the adaptable script to lead to better learning outcomes (because of the opportunity to engage in a more self-regulated form of learning) or to worse learning outcomes (because learners' self-regulation skills may be over-taxed by being granted the opportunity to adapt the script).

RQ 2: To what extent do students' self-regulation skills influence their acquisition of argumentation skills when learning with adaptable and differently structured non-adaptable argumentation scripts?

With respect to RQ2, we hypothesized learners' self-regulation skills to be a significant predictor of their acquisition of argumentation skills in the adaptable script condition, but not in the other two conditions, as in both the low and the high structured script condition, students had no chance (and thus no need to engage in a further reflection of their collaboration) to modify the script.

Methods

Participants were $N = 109$ mathematics students and mathematics teacher students participating in a two weeks preparatory course at university. They were randomly assigned to one of the three treatment conditions: Low structured argumentation script, high structured argumentation script, and adaptable argumentation script. The students learned in three treatment sessions within three consecutive days. For each treatment session, the learners were grouped into new learning dyads to work on a different mathematical proof task. Each learner was equipped with a laptop and a graphical tablet. The two laptops of each dyad were connected via a computer-supported learning environment that displayed the mathematical proof task and a graphical chat environment where the dyads were able to exchange text, formulas and drawings on their ideas to solve the proof task. Beyond that, the dyads could also communicate face-to-face. The computer-supported learning environment also displayed the script prompts which sequenced the discussion and structure of argumentation.

The students were asked to collaboratively discuss their ideas about the proof tasks in all treatment conditions. In the condition with the low structured argumentation script, prompts that were integrated in the chat sequenced the discussion into the steps (1) argument, (2) counterargument and (3) synthesis three times per treatment session. In the condition with the high structured argumentation script students were additionally prompted to formulate sound arguments (e.g. formulating evidence for a claim) in the first and second step. In the condition with the adaptable argumentation script, learners were allowed to choose between the high structured and the low structured argumentation script right before each argument and counterargument step in each treatment session. Overall, an adaptation of the script was thus possible at six points in time per treatment session.

To assess students' argumentation skills, a pre- and a post-test was conducted in which students were asked to describe typical phases and quality features of an argumentative discourse in science. Students' answers were evaluated by two trained coders for the appearance of relevant elements in an argumentative discourse. These were derived from Leitão (2000) for the social discursive phases in an argumentative discourse (relating to the other's arguments when continuing the argumentation, formulating critic against the other's arguments, integrating different arguments). After training, the coders reached sufficient interrater reliability (Cohen's $\kappa = .82$). Self-regulation skills were measured with an eight-items questionnaire (adapted from Fisher, King, & Tague, 2001) in which students rated the extent to which they typically apply certain self-regulation

strategies (e.g.; "I prefer to plan my own learning."; "I am systematic in my learning."). The resulting scale proved reliable (Cronbach's $\alpha = .72$).

Results

Results from a repeated measures ANOVA showed that across all conditions, students' argumentation skills increased significantly between pre- and post-test (see table 1; $F(1,106) = 12.83$, $p < .01$, $\eta^2 = .11$). With respect to RQ1, there were no significant differences in students' learning gains between the three conditions ($F(2,106) = 1.49$, $p = .23$, $\eta^2 = .03$).

Table 1: Mean values and standard deviations for students' performance in the pre- and post-test on argumentation skills

	CSCL script		
	low structure (n = 32) m (SD)	high structure (n = 41) m (SD)	adaptable (n = 36) m (SD)
Pre-test argumentation skills	0.84 (0.88)	0.71 (0.81)	0.61 (0.77)
Post-test argumentation skills	0.94 (0.84)	1.10 (0.80)	1.06 (0.86)

With regard to RQ2, subsequent regression analyses for each condition showed that the students' self-regulation skills were neither a significant predictor for the acquisition of argumentation skills in the conditions with the low structured script ($b = 0.14$, $p = .45$, $R^2 = .02$) nor in the condition with the high structured script ($b = 0.05$, $p = .75$, $R^2 < .01$). However, in the condition with the adaptable script, the students' self-regulation skills had a significant positive influence on the acquisition of argumentation skills ($b = 0.40$, $p < .05$, $R^2 = .16$).

Conclusions and implications

We argued that argumentation scripts may be helpful in fostering students' argumentation skills in the domain of mathematics. Yet, such scripts have been criticized for their rigidity that leaves little freedom for learners to apply their own – potentially functional – strategies ("over-scripting"; Dillenbourg, 2002). Our study therefore investigated the potential of making scripts adaptable as a way to grant learners the opportunity to adjust the argumentation script to their self-perceived needs.

Regarding RQ1, our results indicate that there was no general superiority of the adaptable argumentation script on learners' acquisition of argumentation skills, compared to a continuous (low or high structured) argumentation script. Thus, students on average do not seem to be able to take full advantage of opportunities to adapt scripts to their self-perceived needs. This adds to previous literature that has argued for strong instructional guidance when it comes to help learners acquire new skills (e.g., Kirschner, Sweller & Clark, 2006). What however is surprising is that learners from the high structured script condition did not outperform students from the low structured script condition, given that previous research has typically reported positive effects of stronger forms of scripting especially on more domain-general skills and competences (e.g., argumentation skills or online search skills; e.g., Kollar, Wecker, Langer & Fischer, 2011). Though, the present study differs from many previous studies with respect to the fact that related studies often compare their scripts to completely unstructured control conditions in which groups are simply asked to discuss with each other, without being further supported in this process. In our study, in contrast, also the low structured condition received considerable guidance with regard to the different phases of their argumentation. The fact that, in addition, our coding of the post-test mainly focused on exactly this sequential argumentation strategy (and not, for example, the quality of single arguments or counterarguments) may thus have obscured possible differences between the two conditions.

Regarding RQ2, we found that learners' self-assessed self-regulation skills were a significant predictor of argumentation skills as measured in the post test only in the adaptable, but not in the two continuous script conditions. This confirms our hypothesis that only learners with high levels of self-regulation skills are able to benefit from the opportunity of adapting the script. Thus, the opportunity to consciously decide about the structuredness of the argumentation script, which may be regarded as a genuine act of self-regulation (Järvelä & Hadwin, 2013), can obviously only be taken by learners who already possess a certain level of self-regulation skills. This leads of course to the question how argumentation scripts should be designed that also help students with less functional self-regulation skills. Perhaps, for these learners a longer phase of learning with a continuous (high-structured) argumentation script could be effective, before they are granted opportunities for adaptation. Another possibility might be to offer those students additional instructional guidance on how to

reflect their past scripted learning experience and their actual learning needs in order to make adequate decisions during adaptation.

In further analyses of our data, we aim at investigating the students' adaptation behavior in more detail. The underlying hypothesis is that a more appropriate adaptation behavior in the adaptable script condition should lead to an improved acquisition of argumentation skills. Such an analysis seems important since our measure of self-regulation skills was based on students' self-assessments. Since students do not always adequately assess their own knowledge and skills (Dochy, Segers & Buehl, 1999), an analysis on the basis of real performance data may yield important insights into the validity of our measure. If such an analysis could be done by aid of intelligent tutoring technology (see Diziol et al., 2010), even a successful combination of adaptability and adaptivity might be achieved.

All in all, our study demonstrates that adding flexibility to argumentation scripts (e.g., through making them adaptable) does not seem to reduce their effectiveness with regard to the acquisition of argumentation skills. Yet, only some learners seem to be able to really benefit from this flexibility, i.e. those who already possess a decent set of effective self-regulation skills. Future research should investigate (a) whether these findings also hold true in other domains and (b) ways to help poor self-regulators in their adaptation process.

References

Andriessen, J., Baker, M., & Suthers, D. (2003). Argumentation, computer support, and the educational context of confronting cognitions. In J. Andriessen, M. Baker & D. Suthers (Eds.), *Arguing to Learn: Confronting Cognitions in Computer-supported Collaborative Learning Environments* (pp. 1-26). Dordrecht: Kluwer.

Atkinson, R.K., Derry, S.J., Renkl, A., & Wortham, D.W. (2000). Learning from examples: Instructional principles from the worked examples research. *Review of Educational Research, 70,* 181–214.

Dillenbourg, P. (2002). Over-scripting CSCL: The risks of blending collaborative learning with instructional design. In P. A. Kirschner (Ed). *Three worlds of CSCL. Can we support CSCL* (pp. 61-91). Heerlen, Open Universiteit Nederland.

Diziol, D., Walker, E., Rummel, N., & Koedinger, K. (2010). Using intelligent tutor technology to implement adaptive support for student collaboration. *Educational Psychology Review, 22*(1), 89-102.

Dochy, F., Segers, M. & Buehl, M. M. (1999). The relation between assessment practices and outcomes of studies: the case of research on prior knowledge. Review of Educational Research, 69(2), 145-186. doi: 10.3102/00346543069002145

Fisher, M., King, J., & Tague, G. (2001). Development of a self-directed learning readiness scale for nursing education. *Nurse Education Today, 21*(7), 516–525. doi:10.1054/nedt.2001.0589

Järvelä, S. & Hadwin, A. (2013). New Frontiers: Regulating learning in CSCL. *Educational Psychologist, 48(1), 25-39.* doi:10.1080/00461520.2012.74800

Kirschner, P.A., Sweller, J., & Clark, R.E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75-86.

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

Kollar, I., Ufer, S., Reichersdorfer, E., Vogel, F., Fischer, F., & Reiss, K. (2014). Combined effects of heuristic worked examples and collaboration scripts on the acquisition of mathematical argumentation skills. *Learning & Instruction 32,* 22-36. doi:10.1016/j.learninstruc.2014.01.003

Kollar, I., Wecker, C., Langer, S., & Fischer, F. (2011). Orchestrating Web-Based Collaborative Inquiry Learning with Small Group and Classroom Scripts. In H. Spada, G. Stahl, N. Miyake & N. Law (Eds.), *Connecting Computer-Supported Collaborative Learning to Policy and Practice: CSCL2011 Conference Proceedings, Volume 1 - Long Papers* (pp. 422-429). International Society of the Learning Sciences.

Noroozi, O., Weinberger, A., Biemans, H. J. A., Mulder, M., & Chizari, M. (2013). Facilitating argumentative knowledge construction through a transactive discussion script in CSCL. *Computers & Education*, *61*, 59–76. doi:10.1007/s11412-012-9162-z

Stegmann, K., Weinberger, A., & Fischer, F. (2007). Facilitating argumentative knowledge construction with computer-supported collaboration scripts. *International Journal of Computer-Supported Collaborative Learning, 2*(4), 421-447. doi:10.1007/s11412-007-9028-y

Zemel, A., & Koschmann, T. (2013). Recalibrating reference within a dual-space interaction environment. *International Journal for Computer-Supported Collaborative Learning, 8*(1), 65-87, doi: 10.1007/s11412-013-9164-5

Zimmermann, B. J., & Martinez-Pons, M. (1990). Student Differences in Self-Regulated Learning: Relating Grade, Sex, and Giftedness to Self-Efficacy and Strategy Use. *Journal of Educational Psychology, 82*(1), 51–59. doi:10.1037/0022-0663.82.1.51