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Armin Weinberger, Frank Fischer, Heinz Mandl

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Knowledge convergence in computer-mediated learning environments.

Effects of collaboration scripts

Theoretical Background

So far, *knowledge convergence* has been a widely neglected aspect of collaborative knowledge construction. Collaborative learners contribute their individual knowledge resources, discuss the contributions of their learning partners, and eventually synthesize their individual perspectives. In collaborative knowledge construction groups of learners may be characterized by convergence or divergence of knowledge. Knowledge convergence is defined here as the amount of knowledge concepts that learners share. Different aspects of knowledge convergence can be investigated in collaborative knowledge construction (Fischer & Mandl, 2001). (1) *Resource homogeneity*. Resources of the learning partners, e.g., prior knowledge, may vary or can be highly similar. (2) *Process convergence*. Process convergence means that learners communicate individual knowledge and that learning partners internalize these knowledge concepts. (3) *Outcome convergence*. Finally, the group-to-individual-transfer of shared knowledge must be considered. Outcome convergence indicates to what extent learning partners are able to apply the shared knowledge in the individual condition. Learners may converge with respect to different knowledge aspects. In the context of collaborative knowledge construction, learners may focus on central aspects of a problem case and also regard multiple perspectives on a problem case (Weinberger, Fischer, & Mandl, 2003). In this study we distinguish therefore *focused* and *multi-perspective knowledge* and inquire to what extent learners converge towards each of these knowledge aspects.

Cooperation scripts aim at the facilitation of processes of collaborative learning. Scripts specify, sequence and possibly assign activities to collaborative learners. Learners are expected (or to some degree coerced) to follow the script prescriptions and consequently, engage in productive learning activities (O'Donnell, 1999). These activities can be allocated to various process dimensions in problem-oriented learning environments (Fischer, Bruhn, Gräsel, & Mandl, 2002). (1) Scripts may provide a structure for the *epistemic activities* of collaborative learners. Epistemic activities describe how learners deal with the learning tasks. *Epistemic collaboration scripts* (ECOS) may therefore facilitate process convergence by providing a shared focus on the task. (2) Scripts may also structure the *social modes of interaction of learners*. The social modes indicate how learners interact with each other, e.g., how they relate their contributions to contributions of their learning partners. *Social collaboration scripts* (SCOS) may, for instance, facilitate knowledge convergence by guiding learners to contribute their individual knowledge resources. The combination of both social and epistemic scripts may focus the learners on specific tasks and simultaneously demand learners to share their knowledge resources. Social and epistemic scripts may have differentiated effects on process and outcome convergence, however. Social scripts, for instance, may facilitate process *divergence*. Learners are asked to approach a problem from different perspectives and contribute their individual learning resources. During the collaborative processes learners

may integrate the divergent perspectives and build an elaborated, shared knowledge pool that facilitates outcome convergence.

Objectives of the Study

The objectives of this study are to analyze and facilitate knowledge convergence in computer-mediated learning environments with interfaces designed on grounds of scripts. We investigate the effects of social and epistemic cooperation scripts and their interaction with regard to (1) process convergence and (2) to outcome convergence of computer-mediated collaborative knowledge construction.

Method

SAMPLE AND DESIGN

Ninety-six students in their first semester of educational sciences from the University of Munich participated in this study. The students, who were attending a mandatory introduction course, participated in an online learning session about the theory of attribution as a substitute for one regular session of the course. The theory of attribution (Weiner, 1985) is part of the standard curriculum. Participation was therefore obligatory to attain course credits, but performance in the computer-mediated learning environment did not affect the overall grade. Students were invited individually – each student to one of three different laboratory rooms. Each group of three learners was randomly assigned to one of the four experimental conditions in a 2×2-factorial design. We varied the factors "social script" (none vs. SCOS) and the "epistemic script" (none vs. ECOS).

LEARNING ENVIRONMENT

Students in all experimental conditions had to work together in applying theoretical concepts to three case problems and jointly prepare an analysis for each case by communicating via web-based discussion boards (see figure 1).

They were asked to discuss the three cases against the background of the attribution theory and to jointly compose at least one final analysis for each case, i.e. they usually drafted initial analyses, discussed them, and wrote a final analysis. The cases portrayed typical attribution problems of university students, e.g., a student interpreting his failure on an important test.

All groups collaborated in three discussion boards – one for each case. The discussion boards provided a main page with an overview of all message headers, which were graphically represented in a discussion thread structure. Learners could read the full text of all messages, reply to the messages, or compose and post new messages. In the replies, the original messages were quoted with ">" as in standard newsreaders and e-mail programs.

The social and the epistemic cooperation scripts were implemented with the help of prompts. Prompts were automatically inserted into the text windows of the web-based

discussion boards. When learners responded in the intended way to these prompts, they automatically followed the script prescriptions. The epistemic prompts helped learners to analyze the cases with the help of the attribution theory. The social prompts provided two roles: case analyzer and constructive critic. Learners were automatically guided through the typical activities of the changing roles with the help of prompts.

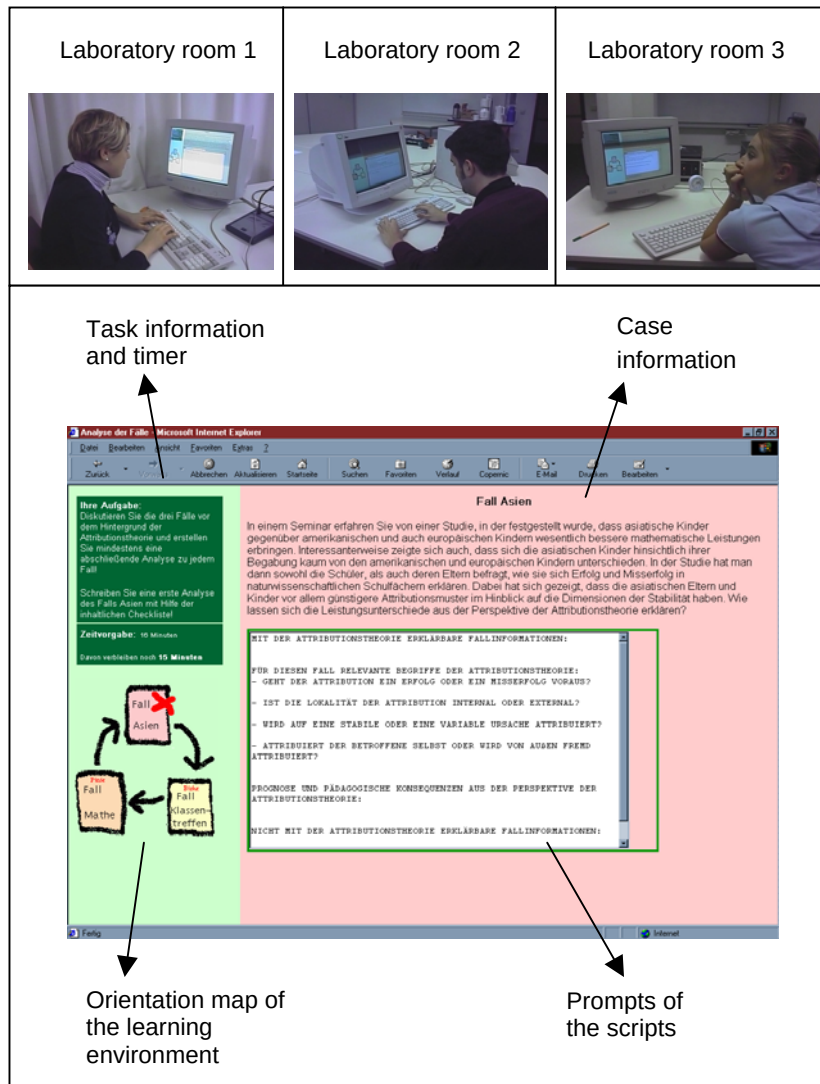


Figure 1: The experimental setup with a learning group of three participants in separate rooms (upper section of the figure) and the computer-mediated learning environment with a web-based discussion board (lower section of the figure).

VARIABLES AND DATA SOURCES

(1) *Process convergence*. The data source of process convergence was the discourse of learners during the collaborative phase. The written discourses were segmented (87% interrater agreement) and analyzed ($\kappa = .90$) with respect to the specific concepts of focused (Cronbach's $\alpha = .77$) and multi-perspective knowledge (Cronbach's $\alpha = .66$) that learners externalized in discourse in comparison to an expert solution. Process convergence was measured on grounds of single comparisons within the groups of three. For instance, learners needed to relate Weiner's (1985) attribution theory concept of an internal, stable attribution with central case information such as "I am not talented". When all three learners of one group externalized this relation between the theoretical

concept, a process convergence value of 3 was credited to the learning group. In case, only two learners externalized this concept-case information relation, a process convergence value of 1 was credited. In any other case, no credits were given. Process convergence was measured with regard to concepts of focused knowledge, such as “internal, stable attribution”, and multi-perspective knowledge, such as “attribution of oneself / attribution of others”. (2) As data source for *outcome convergence* we used the individual post-test. Correspondingly to process convergence, the concepts of focused (Cronbach’s $\alpha = .66$) and multi-perspective knowledge (Cronbach’s $\alpha = .55$) that learners of one group knew to apply in the post-test were analyzed. Outcome convergence was measured on grounds of single comparisons between the three learning partners. In case all learners knew the same concepts, an outcome convergence value of 3 was credited. In case two learners knew the same concepts, an outcome convergence value of 1 was credited.

Results

EFFECTS OF THE SCRIPTS ON PROCESS CONVERGENCE

Process convergence of focused knowledge. The social script substantially affected process convergence regarding focused knowledge aspects ($F(1,28) = 12.26$; $p < .05$; $\eta^2 = .30$), as did the epistemic script ($F(1,28) = 5.67$; $p < .05$; $\eta^2 = .17$). There was an interaction effect as well ($F(1,28) = 14.29$; $p < .05$; $\eta^2 = .34$).

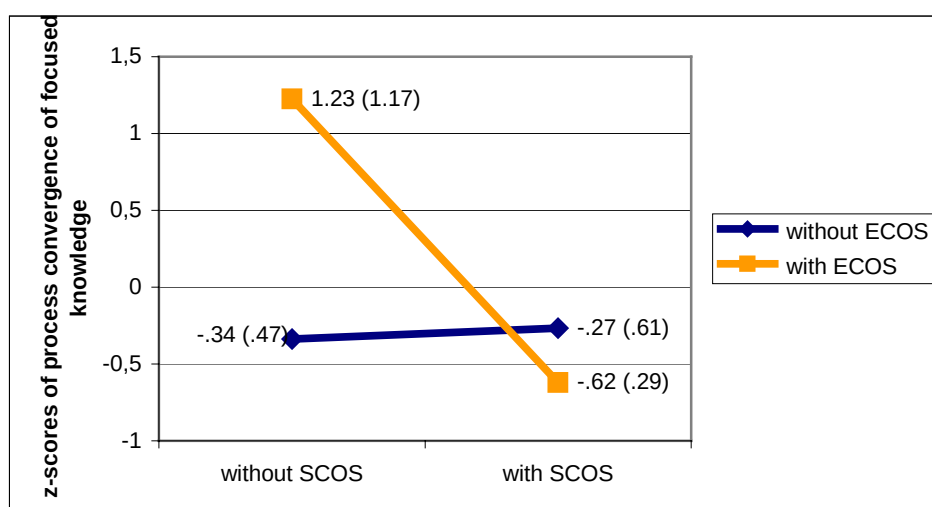


Figure 2: Process convergence regarding focused knowledge in the four experimental conditions (standard deviations in brackets)

Figure 2 suggests that learners who were supported with the epistemic script were highly convergent regarding focused knowledge during the collaborative phase. The social script also improved process convergence, but only slightly. When both scripts are combined, however, learners are more divergent than the control group during the processes of collaborative knowledge construction regarding focused knowledge.

Process convergence of multi-perspective knowledge. With respect to process convergence of multi-perspective knowledge no significant effect, however, of the social script ($F(1,28) = 1.73$; $n.s.$; $\eta^2 = .06$), none of the epistemic script ($F(1,28) = 1.27$; $n.s.$; η^2

= .04), nor an interaction effect of both scripts ($F(1,28) = 2.26$; $n.s.$; $\eta^2 = .08$) could be found.

EFFECTS OF THE SCRIPTS ON OUTCOME CONVERGENCE

Outcome convergence of focused knowledge. No main effects of the social script ($F(1,28) = .06$; $n.s.$; $\eta^2 = .00$) nor the epistemic script ($F(1,28) = 2.70$; $n.s.$; $\eta^2 = .09$), and no interaction effect of both scripts ($F(1,28) = 3.24$; $n.s.$; $\eta^2 = .10$) could be found with respect to outcome convergence of focused knowledge.

Outcome convergence of multi-perspective knowledge. With regard to outcome convergence of multi-perspective knowledge no significant effect of the social script ($F(1,28) = 1.45$; $n.s.$; $\eta^2 = .05$) and no substantial interaction effect ($F(1,28) = 2.84$; $n.s.$; $\eta^2 = .09$) can be observed, but a strong negative effect of the epistemic script ($F(1,28) = 4.69$; $p < .05$; $\eta^2 = .14$).

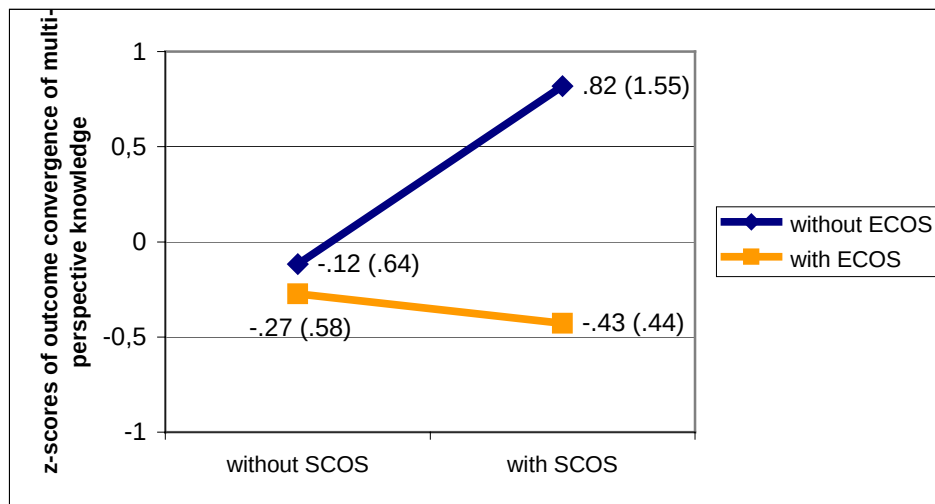


Figure 3: Outcome convergence of multi-perspective knowledge in the four experimental conditions (standard deviations in brackets)

Groups who were supported with the epistemic script showed substantially less knowledge convergence in the individual post-tests (see figure 3). Apparently, the epistemic script impeded the construction of shared knowledge compared to the control group in open discourse.

Conclusions

The findings show that process convergence as well as outcome convergence can be influenced by the prompt-based implementation of scripted cooperation into an online learning environment (Scardamalia & Bereiter, 1996; Nussbaum, Hartley, Sinatra, Reynolds, & Bendixen, 2002).

The social script seemed to foster *process divergence* regarding multi-perspective knowledge. The social roles of case analyst and constructive critic may have motivated learners to contribute their individual resources in discourse. Although the results suggest that the social script facilitates outcome convergence, no significant effect of the social

script on outcome convergence can be found. On grounds of further qualitative discourse analyses it may need to be investigated to what extent learners are enabled to synthesize their resources to a shared perspective and achieve outcome convergence.

The epistemic script proved to support the learners substantially with respect to process convergence, but strongly impeded outcome convergence. The epistemic script may have substituted a shared focus of the learners during the collaborative phase as long as the epistemic script was available to the learners. The convergence of the group regarding specific knowledge concepts could not be transferred, however, to an individual post-test situation. Therefore, the ECOS-learning groups did not actually develop a shared understanding of the application of Weiner's (1985) attribution theory towards problem cases.

The interaction effect regarding process convergence of focused knowledge indicates that the effects of both scripts did not add up as expected in order to facilitate learners to discuss a shared topic and to contribute the individual knowledge resources. Instead, learners provided with both scripts showed more divergence than the control group without instructional support. A possible explanation is that the case analyst role of the social script was modified by the epistemic script and the constructive critics rather needed to search for divergent explanations than to criticize the case analyses.

Educational and Scientific Implications

Knowledge convergence poses an additional goal for any social form of learning, but particularly for collaborative knowledge construction. Knowledge convergence is still poorly understood, however. Learners without additional support rarely achieve knowledge convergence during collaborative knowledge construction. This study on the background of the earlier studies on the topic implicate that knowledge convergence can and should be analyzed and facilitated with scripts. Additional instructional support through scripts presents opportunities, but also poses some risks for knowledge convergence in collaborative knowledge construction. The results suggest that different scripts, implemented in computer-mediated learning environments, may produce differentiated effects on process and outcome convergence of collaborative knowledge construction. Epistemic scripts may help co-workers to focus on specific aspects, but do not foster internalization of shared knowledge. Social scripts, in contrast, may rather facilitate learners to contribute divergent knowledge. This process divergence, however, does not appear to impede outcome convergence.

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