

Supporting learners collaborative knowledge construction by external representations

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Abstract

External representations can be powerful to support learners' collaborative knowledge construction. They can focus learners on aspects which are particularly important for the task to solve. In this study, we investigate different styles of pre-structuring shared external representations, a collaboration script and a content scheme. 159 university students participated in the empirical study. They were assigned randomly in groups of three to one of four conditions in a 2x2-factorial design with the factors of collaboration script and content scheme. Results show that learners benefit particularly from the content scheme. The scheme was able to influence learners' spoken discourse and focused it on aspects necessary for the task solution. Furthermore, also learners' collaboration outcomes benefit from the content scheme.

Keywords: computer-mediated communication; cooperative/collaborative learning; distance education and telelearning; distributed learning environments; human-computer interface

1. Introduction

External representations can be powerful to support learners' collaborative knowledge construction. In the style of a representational guidance, they can focus learners on aspects which are particularly important for the task to solve. Moreover, they could also change learners' perception of a task in a style that learners are able to deal more easily with this task. In videoconferencing, learners benefit from a shared application, which is common for all participants and makes shared external representations to a central part of collaboration. This study investigates how far different styles of pre-structuring shared external representations, either the style of a content scheme or the style of a collaboration script, affect learners' spoken discourse and learners' collaboration outcomes.

2. Background

The term of external representations is a very broad one and describes knowledge and structure which is displayed by physical symbols, objects or dimensions (see Zhang, 1997). Two aspects of external representation have particular importance in the context of learning:

the rather permanent availability of external representations and the feature that can be accessed by different persons at different times. When learners create external representations themselves, they document important steps in their knowledge construction process (see Hayes & Flower, 1980). Furthermore, Peper and Mayer (1986) stress that creating external representations during learning also activates learners' with respect to their cognitive activities. In contrast, when learners work with pre-structured external representations, various learning processes can occur, depending on style of external representation the learners work with. In this paper we focus on external representations which provide structure for the learners. These external representations can focus learners on aspects which are of particular importance for their task. Suthers (2003) calls this mechanism as "representational guidance". Besides this, the representational structure may also have an effect on learners' perception of a task (see Zhang & Norman, 1994). Such a changed perception of a task may enable learners to solve a task better or worse depending on how explicit the structure facilitates learners.

3. Instructional support by external representations.

These effects of external representations can be applied for dedicate instructional support. Thereby, we will focus on two different styles of external representations, either a script for collaboration or content schemes.

Collaboration scripts. If external representations provide explicit support, they are often called *scripts*. Scripts describe important strategies for the learners to solve a task. They often apply methods derived from scripted cooperation (cf. O'Donnell & King, 1999) or cooperative teaching (O'Donnell & Dansereau, 2000). However, these may be rather limited to a sequential application of strategies and only provide representational guidance to a limited extent.

Content schemes. In contrast to scripts, content schemes provide implicit instructional support. They provide and modify the representational context of a task by placeholders for important aspects. This may be realized by either providing facilities for concept mapping (e.g. Fischer, Bruhn, Gräsel & Mandl, 2002; Suthers & Hundhausen, 2001) or by providing tabular structures (e.g. Brooks & Dansereau, 1983; Ertl, Reiserer & Mandl, 2005; Suthers & Hundhausen, 2001). The structure of the scheme remains salient during collaboration and guides and focuses learners during collaboration (see Suthers & Hundhausen, 2001).

4. Research Questions

Research question 1: To what extent can collaboration scripts and content schemes affect learners' spoken discourse?

Research question 2: To what extent can collaboration scripts and content schemes affect learners' collaborative outcomes?

5. Methods

One hundred fifty nine undergraduate students of Education and Psychology took part in this experiment. 53 triads were assigned randomly to one of four experimental conditions in a 2x2-factorial design. We varied the factors of collaboration script (with vs. without) and content scheme (with vs. without).

Learners' task was to solve a case about a pupil's problems in math. They had to conduct an analysis to solve the case according to attribution theory collaboratively. Thereby, it was necessary to extract the important information from the case information and to classify causes, consensus and consistency of the causes and the respective attributions according to

Kelley (1973) and Heider (1958). During the collaboration, learners were connected via a desktop videoconferencing system that included (1) an audio- and video-connection and (2) a shared application to support the learners' collaborative case solution.

Collaboration script. The collaboration script gave the learners a guideline for solving the case which structured the collaboration in four phases and which provided specific activities for each phase:

In the *first* phase, each learner focused on text reading and the extraction of the relevant case information, individually. In the *second* phase, learners had to collaborate to exchange the different information they were given. They were asked to discuss the different causes and their power to explain the pupil's problems in school and to make a proposal for a joint case solution. Then the learners were given five minutes for individual reflection on the appropriateness of this jointly developed case solution (*third* phase). Finally, learners had 15 minutes to find the most plausible solution to the case (*fourth* phase).

Content scheme. Learners who were supported by the content scheme received as tabular pre-structure of the shared application. The content scheme visualized important aspects of the task and thereby provided an implicit strategy for performing an attribution (see figure 1). In the content scheme, the cause of the pupil's problems was the starting point for collaborative case-solving. The next category comprised the concepts of consensus and consistency. For this category, learners had to identify the respective information from the case material and determine whether the particular instance had a high or low value. Based on these determinations, learners then had to identify the corresponding attribution patterns according to the theoretical work of Kelley and Heider.

Cause	Information about		Attribution according to	
	<i>Consensus</i>	<i>Consistency</i>	<i>Kelley</i>	<i>Heider</i>

Figure 1: Structure of the content scheme.

6. Data Sources

To measure the effectiveness of the interventions, the learners' spoken discourse and the collaborative case solution were analyzed.

Analysis of learners' discourse. For analysing learners' discourse, the videoconferencing session was taped and transcribed. The transcripts were segmented into turns and checked for correctness of transcription. Two coders marked each utterance with respect to the categories of "cause", "information about consensus and consistency" and "attribution". The inter-rater-agreement was rather high ($r = .91$).

Analysis of the collaborative case solution. We analyzed the joint case solution, which was created by the in the shared application, as a measure of collaboration outcomes. Correctly identified units of meaning in the category of cause, consensus and consistency and attributions were marked and summed to a score for the respective category. To ensure the

objectivity of the analyses, two raters marked 10% of the documents. Inter-rater reliability of the coding was good ($r = .87$).

Statistical analysis. The statistical analysis was done with SPSS. Results for both research questions were analysed by the multivariate GLM procedure.

7. Results

Research question 1 dealt with the issue about how far the collaboration script and the content scheme were able to affect learners' spoken discourse. Therefore, we will focus on the three important aspects the collaborative task—on causes, on information about consensus and consistency and on the assignment of attributions. In the category of cause were no significant differences ($F_{(4,45)} < 1$; *n.s.*). With respect to the category of consensus and consistency, learners with script uttered descriptively less and learners with scheme uttered more regarding this category. The GLM could prove a significant effect of the content scheme ($F_{(1,45)} = 6.40$; $p < .05$; $\eta^2 = .13$). With respect to the assignment of attributions, learners with script uttered less. However, the GLM revealed no significant differences between the conditions ($F_{(4,45)} < 1$; *n.s.*). Comparing learners' utterances of causes, consensus and consistency and attributions, figure 2 shows that learners of all conditions uttered least about causes, more about consensus and consistency and most about attributions.

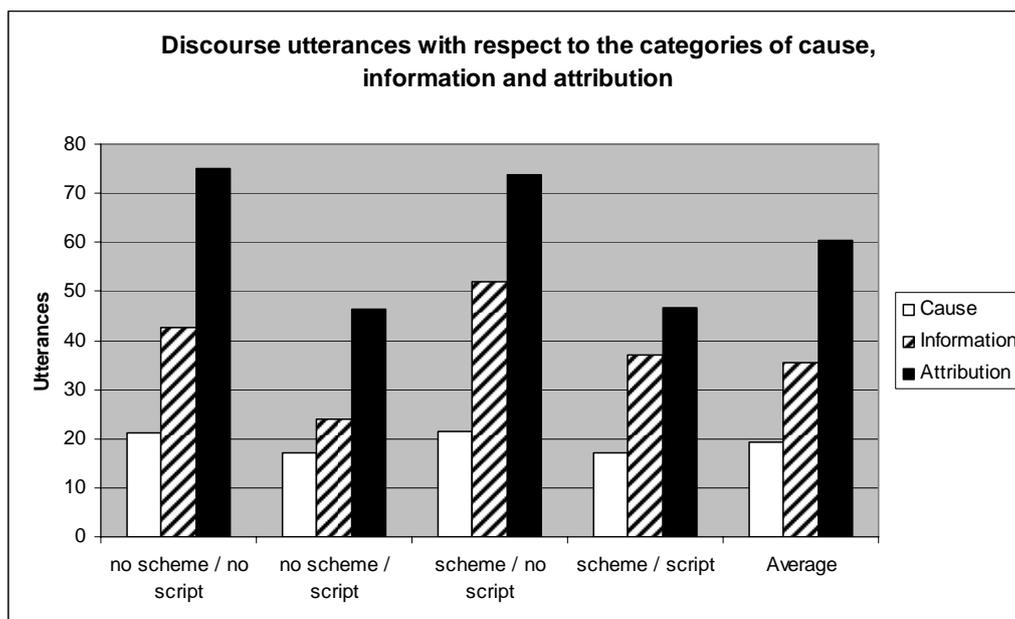


Figure 2: Discourse utterances with respect to the categories of cause, information and attribution.

Looking at *research question 2* and learners' outcomes, we can find differences between the categories of causes, consensus and consistency and attribution. With respect to causes, learners with content scheme noted less than learners without scheme (see figure 3). This effect was significant ($F_{(1,45)} = 6.88$; $p < .05$; $\eta^2 = .14$). Yet, regarding the category of consensus and consistency and regarding attributions, learners with scheme noted more. Learners with scheme noted significantly more about consensus and consistency ($F_{(1,45)} = 38.00$; $p < .001$; $\eta^2 = .46$) and also about attributions ($F_{(1,45)} = 27.47$; $p < .001$; $\eta^2 = .38$). Comparing the values of the three different categories (see figure 3), one can see that learners without content scheme worked more on causes than on information about consensus and consistency while learners with content scheme worked more on information about consensus and consistency.

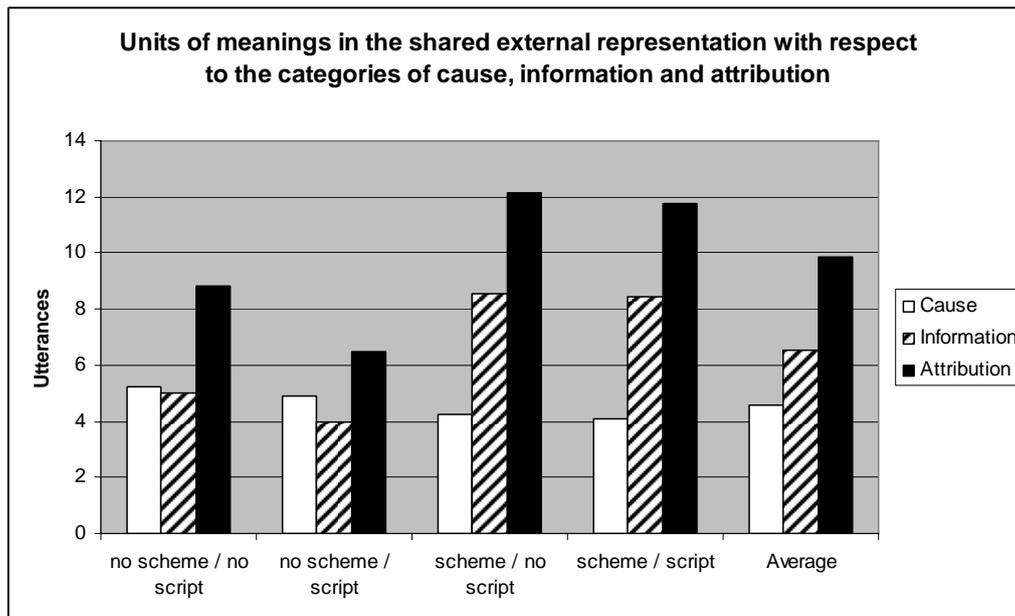


Figure 3: Units of meanings of learners' outcome with respect to the categories of cause, information and attribution.

Summary and discussion. Looking at learners' spoken discourse, the content scheme had an effect on the particular category of determining consensus and consistency. Learners with scheme were engaged more with respect to this category than learners without. This means that the scheme was able to facilitate learners' to work on consensus and consistency. Looking at the script, absolute values make obvious that learners with script made generally less utterances in all categories. This can be attributed to the reduced time of collaborative exchange for the learners with script. Yet, these learners had more time for dealing individually with the case material and respectively for reflecting about the case information. Considering learners' outcomes, the values reveal an interesting result: learners with content scheme were engaged less in providing causes, but more in providing the respective determination of consensus and consistency and in attributing the cause according to Kelley and Heider. The script did not make any differences with respect to learners' outcomes.

The results can disclose some of the particular mechanisms of the content scheme. Looking at the structure of the task, learners had to find causes (1 aspect), they had to determine consensus and consistency (2 aspects) and they had to attribute the cause according to Heider (locality and stability, 2 aspects) and Kelley (one aspect). Therefore, the three categories should occur in the ratio 1:2:3 if applied appropriately. Looking at figure 2, learners kept these proportions quite well during spoken discourse in all of the four conditions. However, regarding the collaborative case solution (figure 3), learners without scheme focused mainly on naming causes but only determined half of the necessary aspects of consensus and consistency and also only a some of the attributions. In contrast, learners with content scheme named less causes, but they provided the respective determinations of consensus and consistency and the attributions for these causes. Therefore, content scheme was able to guide learners during working on the collaborative case solution by representational guidance (see Suthers & Hundhausen, 2001).

With respect to effects of the script, the study could not show any direct influences. Therefore, we have to assume that scripts hardly use the mechanisms of representational guidance—compared to the visual support mechanisms of schemes. Consequently, scripts may need additional trainings for being effective (see Rosenshine, Meister & Chapman, 1996).

Comparing collaboration script and content scheme, both support methods provided similar instructions for the task. However, the one worked as explicit guideline and the other as implicit visualization. This means that learners with scheme did not receive more instructional support, but it was implemented in an implicit style which may be easier for them to follow (see Zhang, 1997).

8. Scientific and educational importance

External representations can be quite beneficial for learning. By the mechanism of representational guidance, they can focus learners on important aspects for their collaborative task solution. This has consequences for the implementation of instructional support for learners. Designers of learning environments should consider how far they need to apply explicit instructional support. Maybe they could apply implicit support mechanisms and reach thereby an improved collaboration process and better collaboration outcomes.

9. References

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