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# Facilitating Knowledge Convergence in Videoconferencing Environments: The Role of External Representation Tools

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## ABSTRACT

The study analyzed how two types of graphical representation tools influence the way in which dyads use shared and unshared knowledge resources in different collaboration scenarios, and how learners represent and transfer shared knowledge under these different conditions. We varied the type of graphical representation (content-specific vs. content-unspecific) and the collaboration scenario (videoconferencing vs. face-to-face). 64 university students participated. Results show that learning partners converged in their profiles of resource use. With the content-specific external representation, learners used more appropriate knowledge resources. However, learners in the videoconferencing scenarios differed from learners in direct collaboration in how they use the representation tools.

## Keywords

Collaborative knowledge construction, knowledge convergence, external representation, shared knowledge, videoconferencing

## BACKGROUND OF THE STUDY

*Knowledge convergence.* A question central to research and practice of computer-supported collaborative learning is, how locally distributed learners manage to converge with respect to their knowledge. In this paper we therefore focus on a theoretical aspect which seems both, highly relevant for the field and so far neglected by empirical research: The aspect of knowledge convergence (Roschelle, 1996). In our analysis we consider two main aspects of knowledge convergence: (1) *Process convergence.* We investigate how group members use the knowledge available to collaboratively construct new knowledge in discourse. Moreover, we analyze how learning partners converge with respect to their discourse focus. It is plausible that cooperation partners develop a kind of collaborative style - even in short-term problem solving activities. (2) *Outcome convergence.* If group members learn together they can construct *shared cognitive representations*. The study of Jeong and Chi (1999) showed that only a relatively small portion of the knowledge, which a dyad constructed in collaboration, is actually represented by both of the learners. A further question is to what extent learning partners are similarly able to *apply* the knowledge in new contexts.

*Facilitating knowledge convergence with shared external representations.* Shared external representation tools might help to improve discourse in computer-supported collaborative learning scenarios (e. g. Fischer, Bruhn, Gräsel, & Mandl, in press). We distinguish between two types of external graphical representation: (a) *Content-unspecific representation:* Tools like shared whiteboards should support interaction between collaborators by providing them with the possibility to visualize graphical elements and written notes. The subject area as well as the task type does not play a role in the design of these tools. In (b) *content-specific representation*, the degrees of freedom of the external representation are constrained by task-related structures. We expected that the provision of this task-related structure in content-specific representation tools would promote the construction of shared knowledge because of a representational bias (Suthers, 2000).

*Videoconferencing.* It is unclear to what extent the conditions of videoconferencing have an impact on process and outcome convergence. Up to this point, no systematic studies on this topic have been conducted. A smaller amount of convergence is possible, for the development of similar positions might be mediated through nonverbal and para-verbal aspects. For example, the lack of eye contact, differences in the visual fields of the partners, as well as the reduced possibility to make deictic gestures in a video conference could serve as hindering factors. However, empirical studies rarely show any differences between videoconferencing and face-to-face conditions concerning the outcome (O'Malley et al., 1996).

## RESEARCH QUESTIONS

(1) Do learning partners converge with respect to discourse focus, knowledge representation, and knowledge transfer? (2) Which effects do the kind of external representation, the collaboration scenario, and their combination have on process and outcome convergence?

## METHOD

(1) *Sample and design:* Sixty-four students of educational psychology volunteered in this study. The participants were separated into dyads and each dyad was randomly assigned to one of the four experimental conditions in a 2x2 factorial

design. We varied (a) the cooperation scenario (face-to-face vs. computer-mediated) and (b) the type of external representation tool (content-unspecific vs. content-specific). Time-on-task was held constant in all four conditions. (2) *Task and learning environment*: Students in both conditions had to work on complex cases in the domain of education. The students' task was to prepare a common analysis of the case. While working on a case, students were provided with a representation tool to visualize their developing solution. Dyads in the *content-specific representation tool* condition worked with a computer-based mapping tool, which provides cards for case information as well as cards for theoretical concepts. Positive and negative relations can be used to connect cards. Learners in the *content-unspecific representation* condition worked on a computer tool with the functionality of a simple graphic editor. (3) *Variables and data sources*: Learning discourse and individual oral evaluation of cases were transcribed and analyzed with respect to the following categories: (a) Discourse focus. Here we distinguish situational, conceptual, application-oriented (the relation of a concept to a case information), and strategic foci. (b) To determine process convergence we computed a similarity index on the basis of the discourse focus categories. (c) As an indicator of outcome convergence we took the quantitative as well as the qualitative differences between the knowledge test results of the learning partners. (4) *Procedure*: After a prior knowledge test, students were made familiar with the learning environment. Next, learners worked together on three cases. The collaboration was followed by an individual post-test.

## RESULTS AND CONCLUSIONS

Results. (1) First, we compared real dyads to nominal dyads (i.e., two learners out of the same experimental condition, who have not learned together). We found higher convergence in real dyads at nearly every discourse focus category as well as for the global similarity measure based on these categories. Second, results concerning outcome convergence showed that real dyads do not differ from nominal dyads with respect to the representation of shared and unshared knowledge. However, more shared knowledge is transferred in real dyads as compared to nominal ones. (2) Compared to the content-unspecific representation, the content-specific representation fosters the use of conceptual and application-oriented focus. This indicates a representational bias effect of the content-specific structure given with the representation tool. (b) We analyzed the quantitative convergence of the learning partners concerning knowledge application in the individual transfer case. Interestingly, for content-specific representation, the convergence is similarly high in both collaboration scenarios. However, for the content-unspecific representation, convergence is low in physical co-presence and high in videoconferencing.

*Conclusions*. (1) We found evidence for process convergence: Learning partners strongly converge to a common profile of resource use. (2) Our findings concerning the shared representation tools could be seen as support for Suthers (2000) representational bias assumption: Learning partners talk much more about specific conceptual aspects, if the external representation provide a task-specific structure. (3) Content-specific representation tools might provide an initial coordination for learners in that they have some task-relevant categories already in their joint problem space as a preliminary common ground. (4) Collaborative knowledge construction and knowledge convergence is neither hampered nor facilitated by the characteristics of our videoconference. (5) The same external representation tool might fulfill quite different functions for the process of knowledge convergence in different collaboration scenarios.

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