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Cognitive Group Awareness Support for Collaborative Discovery Learning

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Abstract:

When learners encounter collaborative multimedia learning scenarios they face certain challenges that can constrain successful learning. Providing knowledge-related information showed to support learners mastering these requirements with regard to collaborative learning with multiple external representations. However, there is no comparable systematic evidence regarding the combination of collaborative learning and scientific discovery learning. This study was designed to close this gap and to investigate whether cognitive group awareness support fosters meaningful collaboration and improves collaborative discovery learning.

Learning dyads were compared in two experimental groups (N = 72), which differed in the level of cognitive group awareness support during collaboration. While learners in one experimental group were provided with a hypothesis tool that contained each learner's assumptions (group awareness support), learning partners in the other group could only see their own assumptions.

Results show that supporting cognitive group awareness by providing knowledge-related partner information improves learning, task performance and knowledge-related conflict resolution. Furthermore, preliminary analyses indicate that group awareness influences communication behaviour: learning dyads that were provided with their learning partners' assumptions spend less effort in knowledge-related grounding activities but are more often engaged in elaborative discussions.

Extended summary:

Introduction

Current multimedia learning environments often combine dynamic features with interactive components such as the possibility of modifying input variables or manipulating certain visual elements. This combination was largely investigated in the field of individual scientific discovery learning and showed to be quite effective for flexible and self-regulated learning (De Jong & Van Joolingen, 1998). If dynamic and interactive visualisations are embedded in collaborative learning scenarios, even more potential arises: Different information, ideas or opinions can be identified and discussed to produce novel, alternative knowledge (Gijlers & De Jong, 2009). However, such scenarios imply specific collaborative challenges for the learners. In order to learn successfully, they have to interrelate complex learning material and communication, to build a common ground, and to structure the collaborative process in a goal-oriented way (Bodemer, 2011; Dillenbourg & Betrancourt, 2006; Fischer, Bruhn, Gräsel, & Mandl, 2002).

A promising approach to support learners overcoming these challenges is to provide them with cognitive group awareness tools that gather and visualise knowledge-related information about their learning partners (cf. Bodemer & Dehler, 2011).

Referring to the extended SDDS model (Gijlers & De Jong, 2005; cf. Van Joolingen & De Jong, 1997) such information can potentially enlarge each learner's individual hypothesis space and

domain space. Furthermore, cognitive group awareness information can help to compare hypotheses and their subjective correctness between learners.

With regard to learning with multiple external representations it showed that group awareness information can foster learning by facilitating grounding processes and by implicitly guiding learners to discuss controversial assumptions (Bodemer, 2011; Bodemer & Scholvien, 2008). Regarding simulation-based discovery learning Gijlers and De Jong (2009) developed a tool that comprised information about learning partners' propositions in a discovery learning scenario. While this tool showed to be effective, the specific benefit of the group awareness component stays unclear, as this component was not varied in isolation.

Based on these findings of Gijlers and De Jong (2009) and Bodemer (2011) the presented study systematically examines the effect of cognitive group awareness on collaborative discovery learning processes. The following assumptions are investigated:

(1) Group awareness support enhances learning and task performance in collaborative discovery learning settings.
(2) Group awareness support facilitates detection and resolution of knowledge-related conflicts.
(3) Group awareness support leads to more meaningful communication behaviour.

Experimental Study

Two experimental conditions were compared, differing in the level of cognitive group awareness support that was provided. While learning dyads in one experimental group were provided with a hypothesis tool that contained each learner's assumptions (group awareness support), learning partners in the other group could only see their own assumptions (cf. Figure 1).

In a preliminary phase two spatially separated learners individually generated hypotheses regarding the analysis of variance. During the following collaborative phase both learners worked in dyads and were provided with the collaboration environment: A shared application which contained an interactive ANOVA visualisation (VANOVA; Oestermeier & Barquero, 2001) and the hypothesis tool they had used earlier (cf. Figure 2). Learners could manipulate several variables within the visualisation to test different scenarios which had been depicted in the hypotheses.

During this collaborative phase both learners were able to individually and independently change their previous settings and to adapt the hypotheses to their current understanding of the concepts. Thus, four different constellations could occur (cf. Figure 3): (1) none of the learners formulated the hypothesis (OO), (2) both partners formulated an identical hypothesis (XX), (3) only one of the learners formulated the hypothesis (XO) and (4) both partners formulated the hypothesis differently (XY). Furthermore, communication was possible by using a text-based chat tool.

72 psychology students (61 females and 11 males) of the University of Tübingen, aged 19–29 years (M = 23.04, SD = 2.33), were randomly paired into 36 dyads and subsequently randomly assigned to the two experimental groups.

Results and Discussion

ANOVAs showed that the experimental groups did not differ with regard to potential confounding variables like time on task or initial distribution of hypotheses. Referring to the assumptions stated above the following results arose:

(1) The first assumption was investigated by measuring individual learning in two knowledge tests which had to be performed prior and subsequent to the collaborative phase (cf. Table 1 for means and standard deviations). An ANCOVA with prior knowledge as a covariate was conducted. As

expected, learners scored higher if they were provided with their learning partner's hypotheses ($F(1, 68) = 5.510$, $p = .022$, $f = 0.283$).

Furthermore, task performance was determined by the number of correct final hypotheses learners had created by the end of the collaboration. The according means and standard deviations are shown in Table 2. An ANCOVA showed that more correct hypotheses were generated if there was group awareness support by displaying the partner's hypotheses ($F(1, 68) = 6.628$, $p = .012$, $f = 0.311$). The number of hypotheses created prior to the collaborative phase was included as a covariate but had no measurable effect on the prediction.

(2) To identify the level of knowledge-related conflict resolution within a dyad the number of final constellations of their hypotheses was analysed. Due to low case numbers the OO- and XO-constellations were not included in the analyses (cf. Table 3). Two ANCOVAs with the number of initial constellations as covariates were performed. As assumed, learning partners solved more knowledge-related conflicts ($F(1, 32) = 3.879$, $p = .057$, $f = 0.343$) and showed higher agreement on their assumptions if they were supported with the group awareness component ($F(1, 32) = 7.765$, $p = .009$, $f = 0.484$).

(3) To preliminary investigate the effect of group awareness support on communication behaviour, chat protocols of eight contrasting cases were chosen and qualitatively analysed. The results indicate that learners with group awareness support seem to put less effort in matching their own with their partner's assumptions, leaving more resources to discuss in a content-related way.

Overall, the results of this study revealed that cognitive group awareness support can improve discovery learning in collaborative scenarios. However, there are still several open questions regarding the potentially beneficial mechanisms underlying the effects, such as how learners use the given information for collaboratively interacting with each other and with the given simulation. For further insight into those mechanisms, interaction analyses of the whole sample are currently conducted including references to the constellations of hypotheses.

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Figures

Figure 1: hypothesis tool (a) with group awareness support, (b) without group awareness support

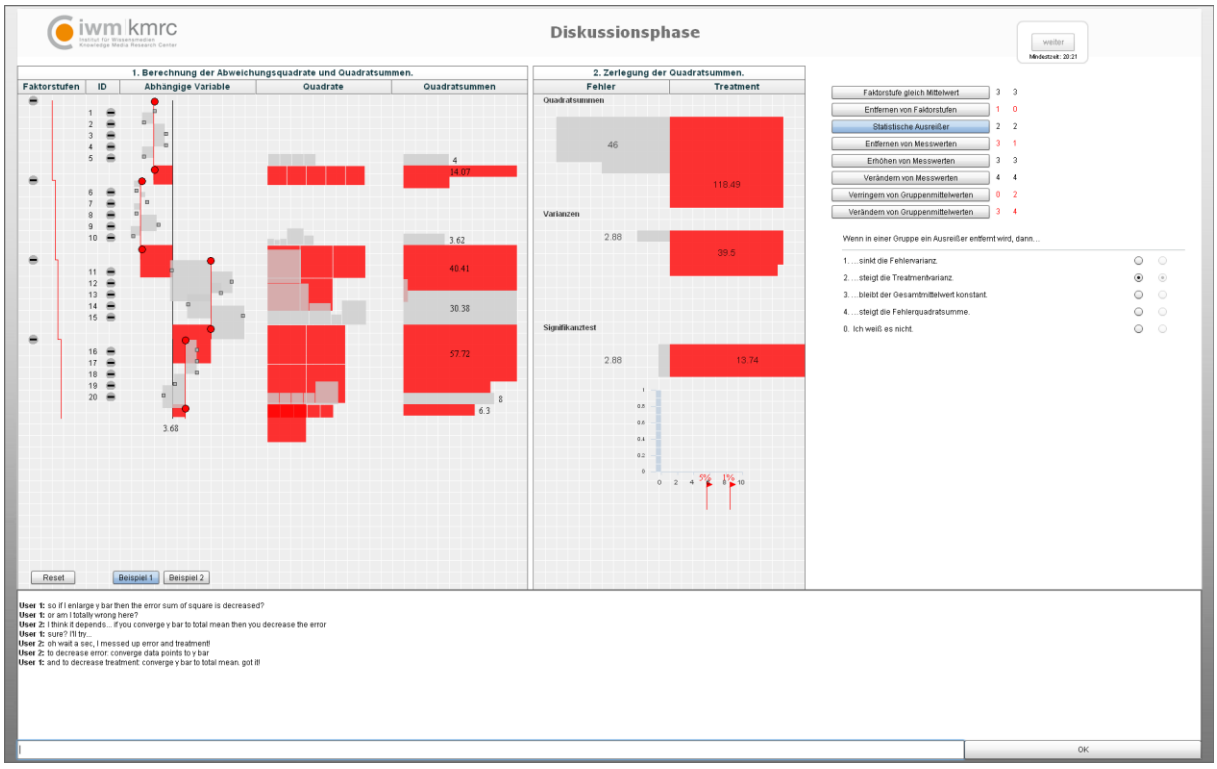

Figure 2: collaboration environment with VANOVA-application, hypothesis tool and chat tool

Figure 3: four possible constellations of partners' hypotheses: (XX) both partners formulated an identical hypothesis, (XO) only one of the learners formulated the hypothesis, (XY) both partners formulated a different hypothesis, (OO) none of the learners formulated the hypothesis

Tables

Table 1: means and standard deviations for knowledge test scores

	knowledge-related partner information					
	with		**without**		**overall**	
	M	*SD*	*M*	*SD*	*M*	*SD*
knowledge test 1 (before collaboration)	51.04	17.52	53.82	20.23	52.43	18.84
knowledge test 2 (after collaboration)	63.37	14.50	55.56	14.47	59.46	14.91

Table 2: means and standard deviations for task performance

	knowledge-related partner information					
	with		**without**		**overall**	
	M	*SD*	*M*	*SD*	*M*	*SD*
number of hypotheses at the end of the collaboration *						
correct	6.19	1.47	5.31	1.70	5.74	1.64
incorrect	1.75	1.52	2.50	1.67	2.13	1.63
missing	0.06	0.23	0.19	0.47	0.13	0.37

*8 hypotheses could be generated

Table 3: means and standard deviations for knowledge-related conflict resolution

	knowledge-related partner information					
	with		**without**		**overall**	
	M	*SD*	*M*	*SD*	*M*	*SD*
number of constellations at the end of the collaboration *						
OO	0.00	-	0.00	-	0.00	-
XX	5.61	2.06	7.11	0.90	6.36	1.74
XO	0.56	0.78	0.11	0.32	0.33	0.63
XY	1.83	2.09	0.78	0.81	1.31	1.65

*8 hypotheses could be generated