Information Cueing in Collaborative Multimedia Learning

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Abstract: Collaborative multimedia learning is a complex and demanding scenario. Differently coded representations, interactive components, and communication have to be managed and processed simultaneously. Focusing learners' attention to relevant information might help to reduce complexity. This study was designed to investigate whether collaborative learning with multimedia can be improved by information cueing, i.e. highlighting essential information in differently coded learning material, and by providing relevant causal relations in interactive learning material. Learning dyads were compared in four experimental groups which differed with regard to information cueing during two subsequent collaboration phases. Learning material comprised multiple static representations (phase 1) and the possibility to manipulate these representations interactively (phase 2). Preliminary results ($N = 24$) indicate that cueing relevant information during collaboration focuses learners' attention to essential aspects, helps to structure their learning discourse, and improves learning outcome.

Introduction

Collaborative multimedia learning is challenging in many ways. Learners have to identify thematically important rather than perceptually relevant information, to interrelate and mentally integrate multiple external representations (MER), to select and systematically manipulate adequate variables in dynamic and interactive visualizations (DIV), to structure collaboration in a goal-oriented way, and to manage all these tasks simultaneously in the realms of their limited working memories (Bodemer, Kapur, Molinari, Rummel, & Weinberger, 2011; Vahey, Enyedy, & Gifford, 2000).

Research suggested various methods for supporting learners in dealing with these different challenges. For instance, in order to enable learners to take advantage of the potential of differently represented information, supporting translation processes between representations has been shown to be beneficial (e.g. linking representations or providing an interactive integration task). With regard to dynamic and interactive visualizations supporting hypothesis testing (e.g., providing pre-defined hypotheses) or constructing basic representational knowledge with different static representations prior to learning with DIV showed to reduce workload and led to better learning. Regarding collaborative learning processes, providing shared representations showed to facilitate grounding processes and proved to support the identification of conflicting knowledge or opinions (Bodemer, 2011).

An instructional suggestion that is relevant for MER, DIV, and collaboration scenarios is to focus learners to relevant information of the learning material: (1) By pre-structuring content in different representations, e.g. via advanced organizers (Gurlitt, Dummel, Schuster, & Nückles, 2012) or by highlighting relevant information (*signaling*; Mautone & Mayer, 2001), and (2) by visually cueing important causalities in conceptual simulations (de Koning, Tabbers, Rikers, & Paas, 2007). (3) In collaborative settings, either applying shared external representations, that implicitly focus the learning partners' activities to the most relevant information (*representational guidance*; Suthers & Hundhausen, 2003) or providing cognitive group awareness-tools, that gather and visualize knowledge-related information about learning partners (Bodemer & Dehler, 2011) proved to guide learners' attention to relevant aspects.

The presented study is starting point of a series of three studies intended to integrate these different research fields and to systematically analyze three underlying mechanisms of cognitive group awareness-tools. This first study examines the effect of focusing learners' attention to essential information in MER-based and DIV-based CSCL. It is investigated if cueing essential information by highlighting relevant elements during MER-based collaboration and by providing essential relations during DIV-based collaboration creates affordances for focused search, communication and elaboration processes. It is assumed that information cueing (H_A) focuses the learning partners' attention to the most relevant information, (H_B) leads to more systematic interaction and communication behaviour, and (H_C) enhances learning outcome.

Experimental Study

In this study two learning partners were provided with interdependent learning material (pictorial vs. algebraic; 15 min). Afterwards they were instructed to collaboratively elaborate on statistics concepts by means of different multimedia learning material in two subsequent phases: (1) During a MER-based collaboration phase (15 min) learners were provided with material that contained formulas and a static visualization of the analysis of variance. To focus learners' attention in a meaningful way, the most relevant visual and formula-based components were highlighted visually in terms of color in two of four experimental groups (MER+/DIV+ and MER+/DIV-). (2) During a DIV-based collaboration phase (20 min) the visualization was augmented by several interactive components, e.g. dragging a group mean to increase or decrease it. Again, in two experimental groups (MER-/DIV+ and MER+/DIV+) information cues were provided by presenting the essential causal relations between variables (cf. Figure 1). Both collaboration phases were conducted using a multi-touch table, enabling face-to-face communication between learning partners.

This presentation reports preliminary analyses based on a subset of 24 university students (12 females and 12 males), aged 19-30 years ($M = 21.83$, $SD = 2.35$). Dyads of participants were randomly assigned to the four experimental groups.

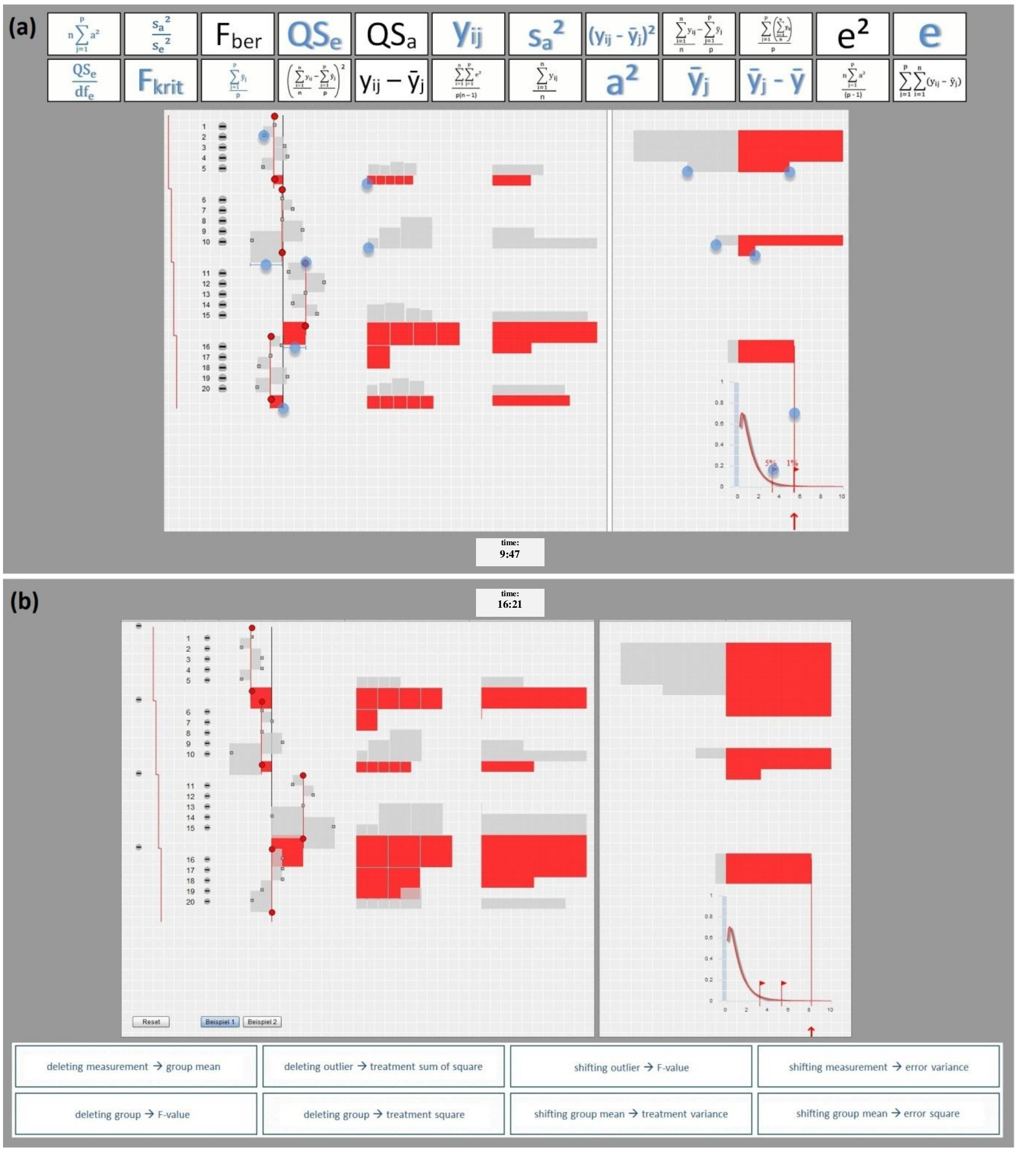

Figure 1. Screen captures of subsequent collaboration phases with information cueing:
(a) phase 1: static multiple external representations with blue solid circles and blue highlighted formulas,
(b) phase 2: dynamic and interactive visualizations with essential causal relations beneath.

Results and Discussion

Due to the preliminary nature of the data, all results are described with a more qualitative focus. After completing full-scale data acquisition, quantitative and more comprehensive analyses will be presented.

(H_A) To investigate the assumption that information cueing helps learning partners to focus on germane aspects, the number of essential concepts identified and discussed by the learning partners was assessed. It revealed that learners addressed more relevant information if they were supported by information cueing both during MER-based collaboration ($M_{MER+} = .73$ vs. $M_{MER-} = .52$) and DIV-based collaboration ($M_{DIV+} = .70$ vs. $M_{DIV-} = .21$). Additional analyses indicate that learners who were provided with information on essential relations generated and tested more goal-oriented hypotheses during DIV-collaboration ($M_{DIV+} = 9.00$ vs. $M_{DIV-} = 5.50$).

(H_B) First analyses of the learning discourses indicate that learning dyads differ in structuring their collaboration and communication depending on whether they have been supported by information cueing or not. During both collaboration phases, providing information cues led to more systematic and effective learning discourses. In the following, examples of characteristic MER-based collaboration processes with highlighted or non-highlighted learning material are given in order to illustrate the influence of information cueing on the learning discourse (cf. Figure 2).

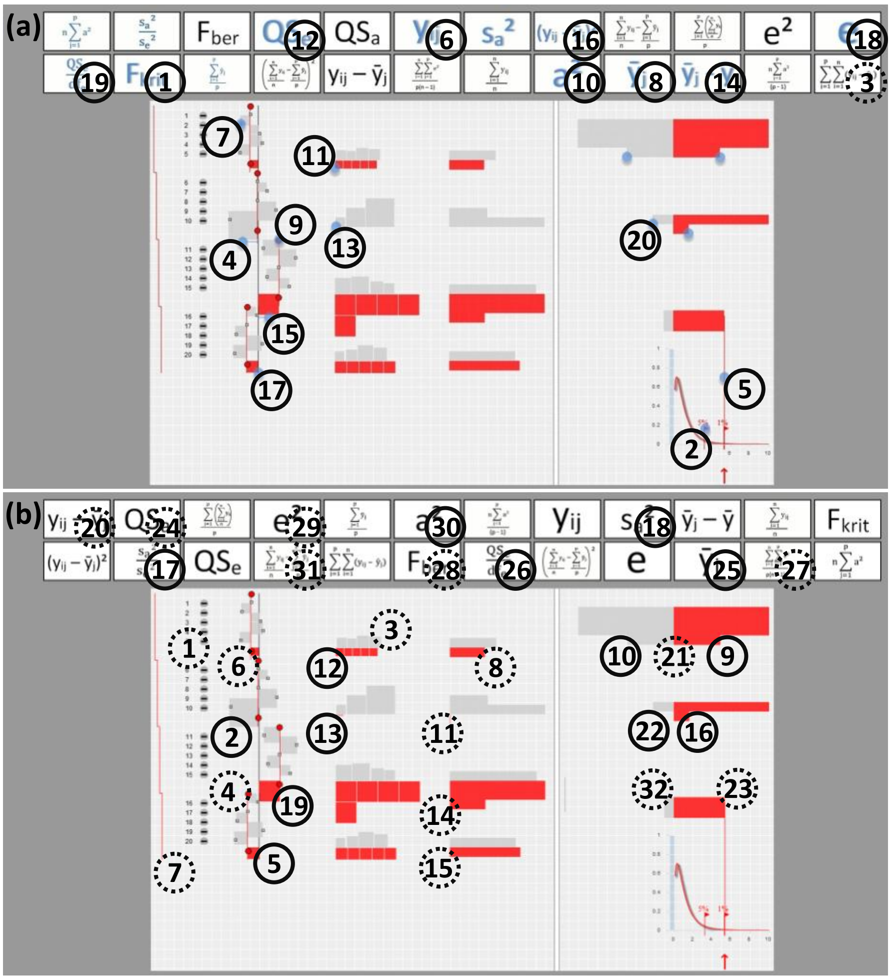

Figure 2. Characteristic MER-based collaboration sequences with (a) highlighted, and (b) non-highlighted material; numbers indicate the sequence of discussion (dashed circles indicate non-essential information).

(a) Learning partners in Figure 2a were provided with material that comprised highlighted cues to essential information. Learners showed a very good interrelation of algebraic and pictorial elements. The sequence of their collaborative learning process was well structured: at the beginning, learners discussed the critical F-value and established references between the two different representations (1-2). They continued with this systematic approach regarding all aspects of ANOVA: basic elements (4-9; measurement, group mean etc.), further crucial concepts like error and treatment effect (10-17) and, finally, different aspects of variance and their meaning for significance of results (18-20).

(b) The learning dyad in Figure 2b was provided with non-highlighted learning material. Concerning different representations, there was very little integration of algebraic and pictorial learning material. Learners exclusively explored and discussed the visualization of the ANOVA during the first half of the collaboration (1-17), before they even started to establish references between formulas and visual components (18-33). This indicates that without information cueing learners' attention is guided by other representational properties, i.e. reading direction and representational affordances of the visualization. Regarding content this dyad showed a rather linear approach at first: they clarified the more basic elements (1-7), and then discussed more complex concepts consecutively (8-17). Afterwards, learners started to integrate formulas and visual elements but, thereby, showed no systematic approach (18-33).

(H_C) Individual learning was measured in three knowledge tests which had to be performed prior (knowledge test 1) and subsequent to the collaboration phases (knowledge tests 2 and 3) (cf. Table 1 for means and standard deviations). On a descriptive level it showed that, as expected, test scores increased if learners were provided with information cues. Results regarding two subtests appear to be especially interesting: cueing information during the MER-based collaboration substantially increased test scores in representational transfer test items, whereas providing information cues during the DIV-based collaboration led to better performances on items, which were designed to quantify intuitive knowledge.

Table 1: Means and standard deviations for general and specific knowledge test scores (%).

	information cueing							
	MER-/DIV-		MER+DIV-		MER-/DIV+		MER+/DIV+	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
general test items								
knowledge test 1	33.33	17.21	37.04	16.73	42.59	14.77	42.59	10.92
knowledge test 2	46.30	16.36	53.70	12.99	50.00	11.65	59.26	9.07
knowledge test 3	47.22	14.38	58.33	15.62	60.19	23.68	70.37	15.18
representational transfer test items								
knowledge test 1	22.22	27.22	22.22	17.21	27.78	25.09	33.33	0.00
knowledge test 2	38.89	25.09	61.11	25.09	33.33	29.81	72.22	25.09
intuitive knowledge test items								
knowledge test 2	55.56	17.21	61.11	25.09	55.56	27.22	61.11	25.09
knowledge test 3	50.00	21.08	61.11	22.77	69.44	28.71	66.67	21.08

Overall, these preliminary results indicate that information cueing focuses learners' attention to essential aspects of multimedia learning material with MER and with DIV. Learning dyads provided with information cues interacted with each other and with the learning material in a systematic and beneficial way: they successfully integrated differently coded representations as well as different aspects of their knowledge. Without information cues, learners' attention was guided more by representational properties which are perceptually relevant (cf. Suthers & Hundhausen, 2003) and less by thematically important information.

Results of this study indicate that focusing learners' attention to relevant information of learning material can reduce complexity and support collaborative learning with different types of multimedia material. Furthermore, these results might partially explain promising effects of cognitive group awareness-tools that provide social information based on essential aspects of the learning material (e.g. Bodemer, 2011).

More comprehensive analyses based on complete data will give further insight into interaction processes, differences between MER- and DIV-based learning, and potential transfer effects between collaboration phases.

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