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Functions of Cognitive Group Awareness Tools

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1. Introduction

Cognitive Group Awareness Tools (CGA tools) provide textual or visual information about others' knowledge, interests, or opinions. They make users aware of the provided socio-cognitive information that can be used in different ways (cf. Bodemer, Janssen, & Schnaubert, in press; Ogata & Yano, 2001). In the learning sciences, such tools are particularly popular for providing implicit guidance (in contrast to explicit guidance: e.g., collaboration scripts) to learners, that is triggering collaboration and communication behaviour intended to be beneficial for learning.

The tools' effectiveness for collaborative learning is usually evaluated on an overall tool level and with a focus on learning outcomes instead of underlying processes. On this basis, research generally indicates that the use of CGA tools can be beneficial for learning (cf. Bodemer & Dehler, 2011). On the other hand, there is also a well-founded reasoning for minor effectiveness and efficiency of information-based guidance approaches (cf. Kirschner, Sweller, & Clark, 2006). In order to identify how CGA tools work, they have to be investigated beyond an overall level and under consideration of the processes potentially affecting the learning outcomes. With a differentiated view, various functions of CGA tools can be identified and distinguished that may trigger cognitive processes.

For example, as a core function, providing knowledge-related information on learning partners might facilitate grounding and partner modelling processes during collaborative learning. However, such information does not only comprise information on a person but also refers to specific and often preselected content (e.g. a learning partner's hypothesis regarding a single element of the learning material), thereby cueing essential information of the learning material and constraining content-related communication. Moreover, CGA tools frequently provide information in a way that allows for comparing learning partners (e.g. adjacently presenting information of two learning partners), thereby guiding learners to discuss particularly beneficial issues, such as diverging perspectives).

Three consecutive experimental studies have been conducted that systematically disentangle these functions for collaborative multimedia learning scenarios by varying only one of the tool features in each study (see Table 1).

Table 1: CSCL challenges and CGA tool support.

CSCL Challenge	Tool Feature	Support/Function	Study
connecting communication and learning material	information cueing	constraining content-related communication	1
establishing a common ground	providing partner information	partner modeling	2
structuring the learning discourse	visualizing knowledge constellations	socio-cognitive guidance	3

2. Method

In each of the three experimental studies, learning dyads were individually provided with interdependent learning material comprising either visual or algebraic information about the ANOVA.

Afterwards, learning partners collaborated in two subsequent phases instructed to collaboratively elaborate on statistics concepts and interrelations by means of multimedia learning material presented on a joint multitouch tabletop (Samsung SUR40 with Microsoft PixelSense): static multiple external representations (MER; phase 1), and dynamic and interactive visualizations (DIV; phase 2; cf. Figure 1).

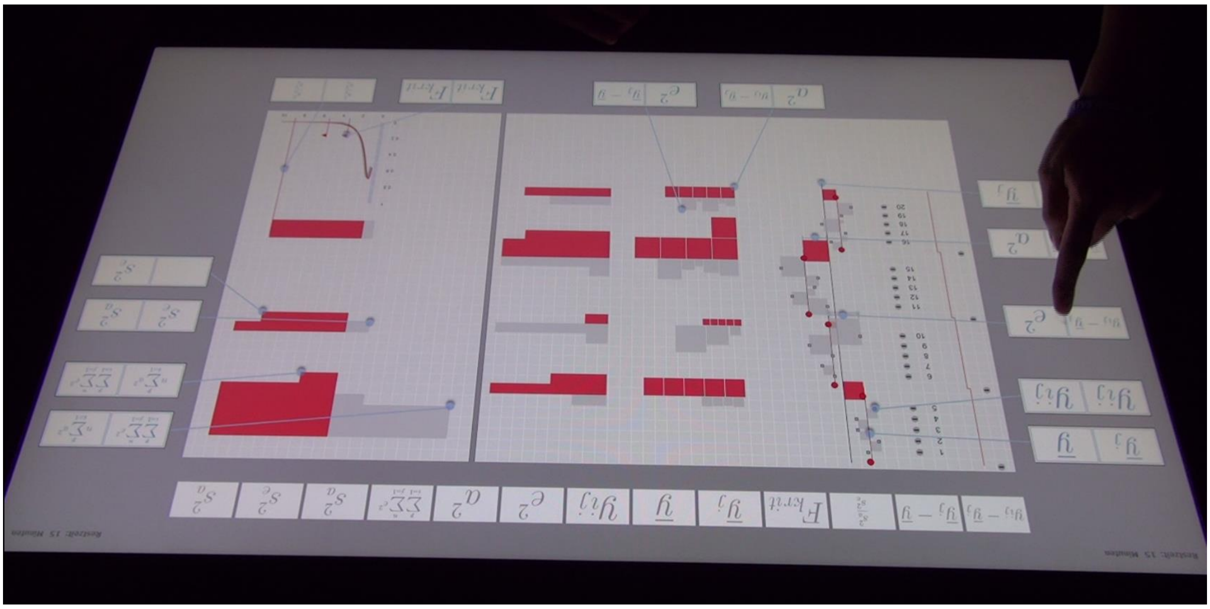

Figure 1. Multitouch tabletop with multimedia learning material (ANOVA).

Additionally, in each collaboration phase, one of the three differentiated CGA tool features was provided in two of four experimental groups, thus leading to four different experimental groups per study (MER0_DIV0 vs. MER1_DIV0 vs. MER0_DIV1 vs. MER1_DIV1; see Figure 2). Knowledge-related CGA information was gathered prior to each collaboration phase by requesting both learning partners to indicate their individual assumptions on the relationship of different elements of the joint learning material.

Individual knowledge tests were conducted before (KT 1) and after each collaboration phase (KT 2 and 3; see Figure 2). Each knowledge test comprised three different subtests to measure conceptual knowledge, representational transfer (Bodemer, 2011) and intuitive knowledge (Swaak & de Jong, 2001). All test items were designed as multiple choice questions, including one correct answer and three distractors.

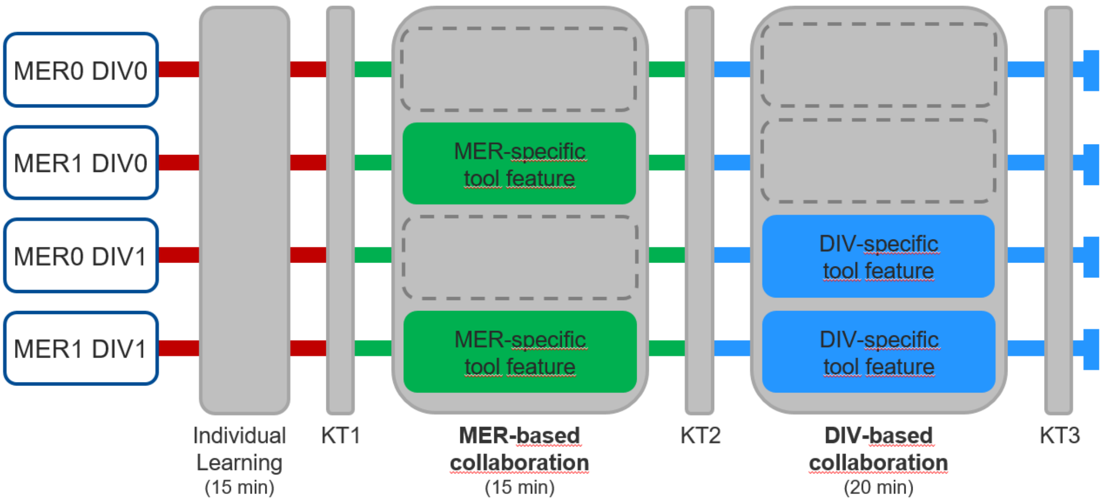

Figure 2. Experimental design and procedure.

3. Results

Study 1 (N = 172) showed better learning outcomes for learners that were provided with information cueing support in terms of highlighted elements and relations in the learning material (phase 1/MER: $F(1, 168) = 9.32$, $p = .003$, $\eta^2 = .05$; phase2/DIV: $F(1, 168) = 18.04$, $p < .001$, $\eta^2 = .10$). Moreover, in analogy to signalling effects in multimedia research (e.g., Mautone & Mayer, 2001), supported learners reported lower mental effort during collaboration. A contrasting exemplary analysis of audio-visual recordings indicates that supported dyads discussed more essential components of the learning material and connected multiple representations more often and more deeply, whereas unsupported learners rather focused on surface features of the representations.

Study 2 (N = 120) also showed benefits of the tool support. Learners provided with knowledge-related information on the learning partner performed significantly better than learners without additional collaboration support (phase1/MER: $F(1, 116) = 4.55$, $p = .035$, $\eta^2 = .04$; phase2/DIV: $F(1, 116) = 29.84$, $p < .001$, $\eta^2 = .21$). Regarding underlying processes, analyses of reminded assumptions of the learning partner indicate that providing cognitive partner information directly facilitates partner modelling during collaboration. However, analyses of the learners' interactions do not support former findings of reduced grounding effort and more elaborated communication.

Study 3 (N = 104) did not reveal a beneficial effect on learning outcomes when learners have been supported by visualized knowledge constellations (phase 1/MER: $F(1, 100) = 0.02$, $p = .894$, $\eta^2 < .01$; phase 2/DIV: $F(1, 100) = 0.01$, $p = .943$, $\eta^2 < .01$). However, process analyses show that learners resolved controversial views more often when provided with visualized constellations and that particularly those learners used this tool feature for elaborated discussions on controversial views that generally perceive complexity as challenging.

4. Discussion

Various functions of CGA tools can be identified and distinguished that may trigger cognitive processes. Three of them have been systematically disentangled and investigated in three consecutive experimental studies for collaborative multimedia learning scenarios: content-related information cueing, providing partner information, and visualising socio-cognitive constellations.

The studies reveal that CGA tools can comprise effective functions that are 'automatically' implemented, such as highlighted information cues that can help learners to connect communication and learning material (study 1). On the other hand, the missing effects of visualized knowledge constellations (study 3) show that well-recognized tool features are not necessarily required in order to trigger the intended learning processes. However, learners were able to make use of the core function of CGA tools for implicitly guided learning processes and better learning outcomes (study 2). Connecting the studies and findings from former research, it seems that the high complexity of the investigated multimedia-based statistics learning scenario rather promoted facilitating tool functions and impeded effects of functions requiring additional mental effort such as comparing and discussing different perspectives.

Beyond the three supporting functions investigated here, effects on learning processes and outcomes can potentially be ascribed to further functions of CGA tools that may affect learning on other levels. For example, on an individual level, collecting and providing knowledge-related information may prompt learners to (re-)evaluate or refocus their individual learning processes (cf. Järvelä et al., 2016). Or, on classroom level, knowledge-related information can be used by teachers to determine and suggest homogeneous or heterogeneous small groups. Other functions may address larger communities and connect cognitive and social group awareness information (cf. Lin, Mai, & Lai, 2015).

Overall, independent of group awareness support, this series of experimental studies demonstrates that disentangling CSCL tools and systematically identifying and evaluating potential functions and processes can help to gain further insights that go beyond overall tool effects.

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References

Bodemer, D. (2011). Tacit guidance for collaborative multimedia learning. *Computers in Human Behavior, 27*(3), 1097-1086.

Bodemer, D., & Dehler, J. (2011). Group awareness in CSCL environments. *Computers in Human Behavior, 27*(3), 1043-1045.

Bodemer, D., Janssen, J., & Schnaubert, L. (in press). Group awareness tools for computer-supported collaborative learning. In F. Fischer, C. E. Hmelo-Silver, S. R. Goldman, & P. Reimann (Eds.). *International Handbook of the Learning Sciences.* New York, NY: Routledge/Taylor & Francis.

Järvelä, S., Kirschner, P. A., Hadwin, A., Järvenoja, H., Malmberg, J., Miller, M., & Laru, J. (2016). Socially shared regulation of learning in CSCL: Understanding and prompting individual- and group-level shared regulatory activities. *International Journal of Computer-Supported Collaborative Learning, 11*(3), 263–280.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*, 75–86.

Lin, J.-W., Mai, L.-J., & Lai, Y.-C. (2015). Peer interaction and social network analysis of online communities with the support of awareness of different contexts. *International Journal of Computer-Supported Collaborative Learning, 10*(2), 139–159.

Mautone, P. D., & Mayer, R. E. (2001). Signaling as a cognitive guide in multimedia learning. *Journal of Educational Psychology, 93*, 377-389.

Ogata, H., & Yano, Y. (2000). Combining knowledge awareness and information filtering in an open-ended collaborative learning environment. *International Journal of Artificial Intelligence in Education*, *11*(1), 33–46.

Swaak, J., & de Jong, T. (2001). Discovery simulations and the assessment of intuitive knowledge. *Journal of Computer Assisted Learning, 17*, 284-294.