

# The Potential of Computer-Supported Collaboration and Knowledge Awareness for Supporting Analogical Problem Solving

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**Abstract:** The present experimental study investigates the impact of computer-supported collaboration and knowledge awareness regarding the source problems the collaboration partner has remembered on analogical problem solving. Collaborating dyads with an external representation for supporting knowledge awareness were compared to collaborating dyads without such an external representation and to a baseline of nominal dyads. Collaborating dyads were less efficient in analogical problem solving than nominal dyads.

## Theoretical Background and Research Questions

Analogical problem solving as a central learning mechanism can be defined as transferring the entire solution process or parts of it from a previous source problem to a new target problem from a more or less disparate domain (Hesse & Klecha, 1990). Individuals, especially novices, often have difficulties in identifying structural correspondences between source problems and target problems, as they mainly focus on surface similarities. Therefore, in the present project, it is assumed that mutual explanation during collaboration on an external representation may stimulate a deeper level of processing, and thus may foster identification of structural correspondences between source problem and target problem (Schwartz, 1995). Furthermore, it is assumed that the postulated positive impact of computer-supported collaboration on analogical problem solving may be amplified by providing an innovative form of group awareness, i.e., knowledge awareness (cf., Engelmann & Tergan, 2007). In this project, it is assumed that knowledge awareness can be achieved by showing each collaborator the text editor window of his collaboration partner, displaying the source problem the partner has remembered as solution relevant for a target problem, respectively. Providing an external representation of the collaboration partner's knowledge allows for a visual comparison of remembered source problems which could result in a higher salience of solution relevant features of the source problems that otherwise may not be identified by both collaboration partners (cf., Suthers, 2001).

## Method

*Participants and Design.* Ninety-six students (64 female, 32 male) of the University of Tuebingen (Germany) participated for either course credit or payment. Average age was 23.15 years ( $SD = 3.70$ ). The students were randomly assigned to one of the following three conditions: (1) collaborating dyads with an external representation for supporting knowledge awareness ( $CD_{ER-KA}$ ;  $N = 17$  dyads), (2) collaborating dyads without an external representation for supporting knowledge awareness ( $CD_0$ ;  $N = 16$  dyads), and, as a baseline condition, (3) nominal dyads consisting of individual problem solvers ( $ND$ ;  $N = 15$  dyads).

*Materials and Procedures.* Participants were told that the study was about computer-supported decision making in the domain of criminal law. First, they filled in a web form stating demographic data as well as a multiple-choice test assessing prior knowledge. After a short (10-15 minutes) training phase of using the software-tool of this experiment, the learning phase (21 minutes) started introducing three kinds of delicts (e.g., which solution steps does the commission delict have?) as well as two worked-out example cases per delict (i.e., source problems). In the following problem solving phase, participants received seven target problems which varied in their surface and structural similarity to the source problems. For example, some target problems were embedded in a highly similar cover story like one of the source problems, but required the application of solution steps of one of the other kinds of delicts. Participants individually had to remember for each target problem and write down in an individual text editor window whether there was a source problem that required solution steps also relevant for this target problem, respectively (25 minutes). Afterwards, participants were randomly assigned to one of three conditions working on the subsequent tasks with time on task held constant. In the first collaborative condition, spatially separated dyads were provided with an external representation for supporting knowledge awareness by inspecting the text editor window of the collaboration partner, displaying the source problems the collaboration partner had remembered (5 minutes). Afterwards, these dyads had to solve the target problems collaboratively by adapting the solution suggested by the source problem to the target problem (30 minutes). The goal was to write a mutual solution of each target problem down in a shared collaborative text editor window. The dyads communicated in this phase via phone conferencing. In the second

collaborative condition, spatially separated dyads also collaborated in order to solve the target problems, but they were not provided with an external representation for supporting knowledge awareness, and thus, could establish knowledge awareness only by means of audio communication. In the baseline condition, problem solvers worked on the target problems completely individually. At the end of the study, as a manipulation check, participants of both collaborative conditions had to indicate in a web form how often (in percentage of the target problems) it had occurred that their collaboration partner had remembered a different source problem in relation to a target problem than the one they had remembered themselves.

*Dependent Measures.* The main dependent measures were correctness of the (collaborative) source problem choice in relation to each target problem and correctness of (collaborative) target problem solution.

## Results and Conclusions

All analyses are based on group level, i.e., on the values of each dyad. The hypotheses were tested by means of planned contrasts.

Univariate analyses of variance (ANOVA) yielded no significant differences between the three conditions regarding age, gender distribution within the dyads (i.e., whether both members of a dyad were same-gender or not), subjective learning preference (i.e., visual vs. verbal learner), experience with computers as well as prior knowledge assessed by the multiple choice questionnaire (all  $F$ s < 1). Average prior knowledge was 16.71 points ( $SD = 1.83$ ) out of 27 points and can be regarded as low to medium.

*Manipulation Check.* Knowledge awareness was analyzed by assessing differences in remembered source problems between both members of a dyad, and by contrasting the deviation of perceived differences from objective differences in remembered source problems. The two collaborative conditions did not differ significantly with regard to their knowledge awareness of differences in remembered source problems ( $CD_{ER-KA}$ :  $M = 0.11$ ;  $SD = 15.60$ ;  $CD_0$ :  $M = 1.34$ ;  $SD = 19.89$ ;  $F < 1$ ).

*Correctness of Source Problem Choice.* A score of dyadic source problem choice was formed indicating whether no member, one member or both members of a dyad had remembered the correct source problem individually in relation to a target problem and whether they agreed on the correct source problem for transferring its solution to the target problem. The planned contrast conducted on the score of dyadic source problem choice yielded no significant differences between the baseline of nominal dyads and the two collaborative conditions combined (ND:  $M = 26.67$ ;  $SD = 4.42$ ;  $CD_{ER-KA}$ :  $M = 27.06$ ;  $SD = 4.18$ ;  $CD_0$ :  $M = 27.00$ ;  $SD = 2.88$ ;  $F < 1$ ). Furthermore, the two collaborative conditions ( $CD_{ER-KA}$  and  $CD_0$ ) performed the task of source problem choice equally well, according to a second planned contrast ( $F < 1$ ).

*Solution of Target Problems.* Nominal dyads worked on highly significantly more target problems ( $M = 8.93$ ;  $F(2,45) = 16.72$ ;  $MSE = 1.48$ ;  $p = .001$ ) than collaborating dyads ( $CD_{ER-KA}$ :  $M = 6.88$ ;  $CD_0$ :  $M = 6.63$ ). In addition, a planned contrast on the scores of correct target problem solution revealed that nominal dyads gained a much higher score ( $M = 49.50$ ;  $F(1,45) = 12.89$ ;  $MSE = 93.52$ ;  $p = .001$ ) than the collaborative conditions ( $CD_{ER-KA}$ :  $M = 38.50$ ;  $CD_0$ :  $M = 38.88$ ) which scored equally ( $F < 1$ ). Nevertheless, the confidence ratings of the nominal dyads concerning having the target problems solved correctly provided that the solution was correct were significantly lower ( $M = 18.98$ ;  $SD = 11.20$ ) than the corresponding confidence ratings of collaborating dyads without an external representation for supporting knowledge awareness ( $M = 28.66$ ;  $SD = 11.20$ ;  $p = .05$ ), but did not differ from the confidence ratings of collaborating dyads with an external representation for supporting knowledge awareness ( $M = 27.09$ ;  $SD = 10.42$ ;  $p = 10$ ).

To sum up, in this study, it could not be confirmed that collaborating dyads identify solution relevant aspects of source problems more often than individual problem solvers do and that an external representation for supporting knowledge awareness improves collaborative analogical problem solving. Nevertheless, computer-supported collaboration has a high potential for supporting analogical problem solving, because the need to externalize and negotiate solution relevant source problems may prevent learners from considering only superficially similar problems. Future research is needed to clarify the impact of knowledge awareness and to develop computer-supported environments that are highly adapted to the requirements of collaborative analogical problem solving.

## References

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