Learning Complex Scientific Concepts through Peer Interaction: The Effect of Human Presence and Discourse Style

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Abstract

This study aims to further our understanding of the processes underlying the learning of complex science content through argumentative discourse. We report on findings from a controlled study that tested the effect of the role of human presence on learning by manipulating the belief of interaction with a human or a computerized peer agent. The effect of competitive vs. collaborative argumentative discourse style on learning from computer-mediated interaction with a disagreeing peer is also explored. Peer confederate's verbal behavior was tightly controlled and scripted to evoke argumentative discourse, holding content exposure constant but differing in rhetoric style according to condition. Even though previous studies have reported that the belief of interaction with a human peer benefits learning in consensual settings, we found the opposite for a settings in which the partner disagrees with and critiques the learner's own solutions: Students showed higher learning gains when they believed they interacted with a computer agent as opposed to with a human peer. Moreover, results from this study show the importance of collaborative discourse goals in learning from argumentation.

Keywords: Conceptual change, social presence, discourse goals, social regulation.

Objectives

The study reported here is part of a line of research into the motivational and affective dimensions of learning through peer argumentation and peer refutation. Specifically, we examined whether the mere belief that one is interacting with a disagreeing conversational peer agent as opposed to a human peer affects learning from this type of interaction. We also explore whether a conversation partner's argumentative discourse goals (competitive vs. constructive) affected students' learning gains on conceptual change tasks.

Theoretical framework

Research and theory on conceptual change indicates that socio-cognitive conflict can serve as a trigger for the restructuring of misconceptions, provided that students are given adequate opportunities and support to work through, understand and articulate the differences between the two conflicting explanations, for example through the use of argumentation (e.g., Asterhan & Schwarz, 2007; 2009; Nussbaum & Sinatra, 2003). However, students often avoid the direct confrontation between their own intuitive conceptions and alternative explanations proposed by another person, and instead prefer to concede upfront or hold on to their initial standpoint

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without much cognitive engagement, therefore missing important opportunities for learning (Asterhan, in press).

The present study is part of a line of research that explores the motivational and affective states that may support or inhibit students to critically consider and productively discuss alternative explanations to their own misconceptions of complex scientific topics, when asked to interact with a disagreeing peer partner. In particular, we focus on the role of belief in social interaction in learning through argumentation with a disagreeing partner. Improvements in conversational agents are being made at a rapid pace and it may not be long before students are asked to engage in natural conversations with computer agents, instead of with human agents. One may even assume that one day conversational agents will be able to mimic the essential aspects of human argumentative discourse, albeit within a specified domain. If this is the case, then one may ask if, other things being equal, the benefits from interacting with a conversational agent can be expected to be similar to, smaller than or larger than comparable interaction with a human agent? The question of how the belief that one is interacting with a computerized peer agent instead of a human peer will affect learning is then a timely one. Exploring this question will not only provide valuable information with regard to task design, but it will also give insight to the workings of learning through interaction. In other words, what is the role of the social dimension inherent to human-human conversation for learning from interaction? Previous research has shown that the mere belief that one is interacting with a human (as opposed to a computerized) agent benefits learning in consensual human-agent interactions, such as tutoring (Rose & Torrey, 2005) or reading explanations and asking informative questions (Okita, Bailenson & Schwartz, 2008). However, the opposite may be true for interactions with a *disagreeing* partner. Interacting with a disagreeing computer agent may be less threatening than with a human partner and therefore more beneficial for learning. The current study then aims to explore the effect of the belief of human presence on learning from interacting with a disagreeing partner.

The second goal is to study the effect of competitive and collaborative discourse goals in argumentative interaction on learning. Argumentation may be regarded as a competition between individuals (who is right?) or between ideas (which idea is right?). A focus on the interpersonal, competitive dimension of argumentative discourse may raise concerns about self-competence (Butera & Mugny, 1995; Pool, Wood & Leck, 1998), group belonging and interpersonal relationships, leading to a reduction in cognitive flexibility and openness to alternative viewpoints (Carnevale and Probst, 1998), or causing students to concede upfront without further consideration and engagement (Asterhan, in press; Smith, Johnsson & Johnsson, 1981; Weinberger & Fischer, 2006). Conversely, when disagreements and argument are perceived in terms of a collaborative effort to critically explore different alternatives, students are expected to benefit from the cognitive affordances that argumentative discourse has to offer.

In a previous study (Authors, 2010), we showed that manipulating students' discourse goals affect the way dyads regulate interaction and that these difference are in turn associated with learning differences, but a *direct* link between interpersonal regulation and learning could not be established. Other works have reported anecdotal and qualitative evidence for the potential effects of these two argumentative discourse styles on learning (Asterhan , in press; Berland & Hammer, 2012; Keefer et al, 2000). In the current study we then seek to isolate the effect of competitive vs. collaborative regulation during online argumentation in a controlled experimental design.

The concept of diffusion was chosen as the content domain. As described by Chi (2004), understanding the concept of diffusion is typically found to be challenging for students because of the concept's underlying emergent structure: The flow-like, ordered pattern that can be perceived on the macro (aggregate) level, emerges from an unordered random Brownian motion of the molecules on the micro (individual objects) level. Whereas students easily grasp the macro-level attributes and their determinants, the difficulty lies in understanding the micro-level process and the emergence of the macro level from it.

Method

Eighty undergraduates (40 males and 40 females) from a large university in the Jerusalem area with no formal schooling in Biology were accepted for participation. A pretest-interaction-posttest, 2 X 2 experimental design was employed. Each student was randomly assigned to one of four conditions within gender, individually invited to the lab and participated in a 1.5 to 2 hrs learning sequence consisting of the following steps:

Phase 1: Administration of pretests, a demographical survey and 3 self-report surveys measuring motivational constructs (i.e., achievement goal orientations, cognitive closure and argumentativeness).

Phase 2: Individual preparation, in which each student studied an excerpt from a standard Biology curriculum textbook, explaining the process of diffusion and its role in the respiratory system.

Phase 3: Computer-mediated dialogue, in which students discussed their answers to two transfer items through computer-mediated dialogue (Google chat) with a same-sex, equal-status peer (human or computer agent), who in fact was a human confederate. The interaction was scripted so that the human / computer agent peer was always assigned the role of the question-asker and the student that of answering these questions. The confederate then asked the student to write his/her solution to a test item, requested him/her to further clarify the solution, questioned the correctness of the student's solution by referring to a common misconception about diffusion, presented an alternative explanation, and solicited the student to reflect on his/her own understanding. Content-wise, the confederate's prompts and questions were held constant across conditions. The conversational style of the confederate' communications differed per condition however: They included linguistic cues that conveyed either a competitive discourse goal (e.g., "I do not think so. It is clear to me that it cannot be X", "That does not seem to make sense. Do you really think that Y?") or a collaborative discourse goal (e.g., "I am not so sure…. It does not seem likely that X", "I am not an expert in this, but is it really true that Y?") (see Author, in press, for details). The design of the confederate's discourse style was based on previous work (a/o, Author, in press; Brown & Levinson, 1987; Chiu & Khoo, 2003) Students then filled out self-report surveys measuring features of their interaction experiences such as perceived social presence.

Phase 4: Delayed posttest, a week following T3, assessing both factual recollection as well as conceptual understanding of diffusion and the role of diffusion in the respiratory system. The following learning measures were obtained: (1) factual recollection; and (2) overall conceptual understanding of diffusion, which is further subdivided into (a) diffusion at the micro level and (b) diffusion at the macro level.

Results

Analyses of variance were conducted with the following two covariates: individual performance at pretest and immediately following the reading of the textbook excerpt. As expected, a main effect was found for belief of social interaction (a human vs. computer agent peer), F (1, 70) = 4.36, p = .040, η_p^2 = .06, such that students that believed they interacted with a computer agent showed better conceptual understanding than students in the human peer condition. No significant differences between conditions were found specifically on the micro level/ macro-level principles scores, or on factual recollection.

As expected, students in the constructive style condition showed better overall conceptual understanding than students that participated in the competitive style condition, F (1, 70) = 5.48, p = .022, η_p^2 = .07. They also did not differ with regard to micro level principles, factual recollection of information or macro-level principles. No interaction effects were found.

Discussion and significance

Previous research has shown that believing that one is interacting with a human (vs. a computerized) agent is more beneficial for learning. However, the findings reported here indicate that this may be limited to consensual verbal interactions and not apply to settings in which the learner's conceptions are critiqued: Regardless of the partner's discursive style, students gained more from interacting with a disagreeing peer when they believed him/her to be a computer agent, as opposed to a human peer. We suggested that this difference may be explained by a decrease in the extent to which the situation was experienced as threatening by participants. Analyses of the protocols and the video streams of the participants' behavior during the interaction are expected to shed more light on this question.

In addition, students learned better when the disagreeing partner's argumentative discourse goals were collaborative and constructive, as opposed to competitive. The results then emphasize the importance of meticulous framing of discourse goal instructions if argumentation is to be used as a vehicle for learning complex scientific content. Emphasizing the competitive and adversarial sides of argumentation, such as is often the case in debating activities in classrooms, may be counterproductive.

References

Asterhan, C.S.C (in press). Competitive and collaborative regulation of peer argumentation: Conceptualization and quantitative assessment. To appear in M. Baker, J. Andriessen & S. Jarvela (Eds), *Affective learning together*. New York, NY: Routledge, Advances in Learning & Instruction series.

Asterhan, C.S.C , Butler, R. & Schwarz, B.B. (2010). Goals for learning and interaction in argumentation and conceptual change. *Proceedings of ICLS 2012*.

Asterhan, C.S.C & Schwarz, B.B.(2007). The effects of monological and dialogical argumentation on concept learning in evolutionary theory. *Journal of Educational Psychology, 99,* 626-639.

Asterhan, C.S.C & Schwarz, B.B. (2009). The role of argumentation and explanation in conceptual change: Indications from protocol analyses of peer-to-peer dialogue. *Cognitive Science*, *33*, 373-399.

Berland, L. K., & Hammer, D. (2012). Framing for scientific argumentation. *Journal of Research in Science Teaching*, *49*, 68-94.

Brown, P. & Levinson, S. C. (1987). *Politeness: Some universals in language usage.* Cambridge: Cambridge University Press.

Butera, F. & Mugny, G. (1995). Conflict between incompetences and influence of a low-expertise source in hypothesis testing. *European Journal of Social Psychology, 25*, 457-462.

Carnevale, P.J., & Probst, T. (1998). Social values and social conflict in creative problem solving and categorization. *Journal of Personality and Social Psychology*, 74, 1300-1309.

Chi, M. T. H., (2005). Commonsense conceptions of emergent processes: why some misconceptions are robust . *The Journal of the Learning Sciences*, *14*(2)*,* 161–199.

Chiu, M. M. & Khoo, L. (2003). Rudeness and status effect during group problem solving: Do they bias evaluation and reduce the likelihood of correct solutions? *Journal of Educational Psychology, 95*, 506-523.

Keefer, M. W., Zeitz, C. M. & Resnick, L. B. (2000). Judging the quality of peer-led student dialogues. *Cognition & Instruction, 18,* 53-81.

Nussbaum, E. M., & Sinatra, G. M. (2003). Argument and conceptual engagement. *Contemporary Educational Psychology, 28*, 384-395.

Okita, S., Bailenson, J. & Schwartz, D. L. (2008). Mere belief in social action improves complex learning. *Proceedings of ICLS 2008*.

Rose, C. P. & Torrey, C. (2005). Interactivity and Expectation: Eliciting Learning Oriented Behavior with Tutorial Dialogue Systems. *Proceedings of Interact 2005.*

Tjosvold, D. & Johnsson, D. W. (1978). Controversy within a cooperative or competitive context and cognitive perspective taking. *Contemporary Educational Psychology, 3*, 376-386.

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