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Finding Productive Talk Around Errors in Intelligent Tutoring Systems

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Abstract: To learn from an error, students must correct the error by engaging in sense-making activities around the error. Past work has looked at how supporting collaboration around errors affects learning. This paper attempts to shed further light on the role that collaboration can play in the process of overcoming an error. We found that good collaboration is more likely to happen after an error occurs *and* after a student has requested and discussed a hint with their partner than at either of these points separately. These finding suggest that cognitive support can enhance collaborative sense-making of errors.

Keywords: Educational technology, Dialogue analysis, and Computer-supported collaborative learning

Introduction

Research in both individual and collaborative learning indicates that errors can be good moments of learning (Koedinger & Aleven, 2007; Ohlsson, 1996). Rummel, Mullins, and Spada (2012) suggest that performing collaborative sense-making activities around errors can be beneficial for learning and may lead to students making fewer errors on future problem-solving steps. In addition, hints have been shown to be effective in supporting individual learning with an intelligent tutoring system (ITS), provided students use them appropriately (Koedinger & Aleven, 2007). However, students often engage in poor help-seeking behaviors, for example by not requesting a hint when one would be useful or engaging in hint abuse (Roll et al., 2014). Although Rummel, Mullins, and Spada (2012) explored how collaboration scripts can support students to take advantage of the system feedback around errors, their study does not address specifically how collaboration can be most beneficial in learning from errors and what role hints play in the process. In the current paper, we investigate the degree to which and the conditions under which interactive dialogue, as defined by Chi's (2009) ICAP framework, happens around errors. We also study whether/how dialogue and system-provided hints can work together to support learning. Chi proposes that interactive activities are more conducive to learning than constructive, active, or passive activities. Interactive activities include collaboration where there is giving and receiving of explanations along with co-construction of knowledge (Hausmann, Chi, & Roy, 2004; Chi, 2009). In order to better understand the role that collaboration can play in overcoming and learning from errors, we first looked at the types of collaborative talk that were associated with subgoals in ITS problems on which errors were made. Based on our findings, we then did an in depth analysis of four dyads selected randomly, looking at subgoals with errors to see how the talk was influenced by the ITS feedback.

Methods

Our data is a set of collaborative data in which 26 4th and 5th grade dyads, paired within a grade (i.e. 13 4th and 13 5th grade dyads), engaged in a problem-solving activity in a collaborative ITS for fractions learning. Problem sets were developed using standard ITS support with step-level support for problem solving (immediate feedback and hints). Each student had their own view of the collaborative ITS while they were synchronously working on a problem and communicated through Skype. The collaboration was supported through three different features: assigned roles, individual information, and cognitive group awareness. Each dyad worked with the tutor for 45 minutes in a lab setting at their school. All activities on the ITS were recorded in a tutor log including hint requests and errors. Students' conversations during the collaborative problem solving were recorded and later rated.

The rating scheme consisted of four major code categories: interactive dialogue, constructive dialogue, constructive monologue, and "other". For our analysis, we focused on the interactive dialogue category, in which students engage in actions such as co-construction and sequential construction. Interactive dialogue aligns with ICAP's joint dialogue pattern (Chi, 2009). Our rating scheme was developed to look at groups of utterances associated with subgoals (i.e., a group of steps that all are for the same goal within a problem) to account for the interactions between the students. An inter-rater reliability analysis was performed to determine consistency among raters (Kappa= 0.72).

Findings

The average number of subgoals completed per dyad was 59.2 (SD = 24.6) and 78.59% had talk. Of subgoals that had talk (1196 subgoals), 26.6% had at least one error. To investigate the association between errors and interactive dialogue, a hierarchical linear model with two nested levels was used to analyze how the talk during subgoals related to the number of errors made. At level 1, we modeled errors for each of the talk types and each of the collaboration features for the subgoals. At level 2, we accounted for random dyad differences. Since there was no effect for collaboration features, it was removed from the model. We found a significant difference in the number of errors associated with the different talk types, $F(3, 1189) = 10.91$, $p < .001$. Post hoc analyses indicated that the average number of errors was significantly higher where *interactive dialogue* took place compared to the "other" talk category ($p < .001$).

To better understand the patterns of talk that occur around errors, we performed a qualitative analysis on the errors. Four dyads were chosen at random, of which three had above-average learning gains whereas the fourth dyad had below-average learning gains. The four dyads had 61 subgoals in which errors occurred (M = 15.25, SD = 4.99). Of these subgoals, 59% had only one error (M = 2.31, SD = 2.55). Students having interactive talk on a subgoal did not guarantee that they had interactive talk after an error occurred. Of the subgoals that had interactive talk, only 33.3% also had interactive talk occur after the error as well. When interactive talk occurred during a subgoal but was not present after an error, the students would try to answers without any discussion. Knowing that an error was made did not provide enough support for the students to engage in a productive conversation. When *interactive talk* happened *after* an error occurred, in 88% of these cases, it was prompted by the students asking the tutoring system for a hint. 90.1% of the subgoals with errors did not elicit any interactive dialogue after the error and in these cases the students did not discuss any hints. Thus, it appears that the hint provided a starting point for the discussion and a way to engage in the interactive talk. For the subgoals on which there was no interactive talk before or after the error, often the students would try to guess the correct answer without discussing their reasoning behind the proposed answers. Even when the tutor logs showed that a hint was requested, which both students could see, the students did not discuss the hint.

Conclusions

Under what conditions does interactive talk happen after an error occurs? Previous work has looked at how supporting collaboration around errors affects learning. We build upon this by showing that errors are an opportunity for collaborative sense making after students are aware of the misconception *and* request a tutor hint, which provides some measure of support for interactive talk. The hints provided a starting point for a conversation by providing domain related talk that the students could use in their conversation. When students did not discuss a hint, they often did not have a productive conversation and instead guessed and checked. These findings imply that to support collaborative learning effectively, it may not be enough to just encourage students to collaborate when students are struggling as was done in Rummel, Mullins, & Spada (2012). Especially for younger students, who are still developing the vocabulary needed for effective discussions in STEM domains, it may be important to provide hints, which can serve as starting points for the domain discussion when students make errors. A next step for this research would be to see if interactive talk that happens after errors are made is correlated with learning.

References

Chi, M.T.H. (2009) Active-constructive-interactive: a conceptual framework for differentiating learning activities. *Topics in Cognitive Science, 1,* 73-105.

Hausmann, R. G., Chi, M. T., & Roy, M. (2004). Learning from collaborative problem solving: An analysis of three hypothesized mechanisms. In *conference of the Cognitive Science society* (pp. 547-552).

Koedinger, K. R., & Aleven, V. (2007). Exploring the assistance dilemma in experiments with cognitive tutors. *Educational Psychology Review*, *19*(3), 239-264.

Ohlsson, S. (1996). Learning from performance errors. *Psychological review*,*103*(2), 241.

Roll, I., Baker, R. S., Aleven, V., & Koedinger, K. R. (2014). On the Benefits of Seeking (and Avoiding) Help in Online Problem-Solving Environments. *Journal of the Learning Sciences*,.*23*(4), 537-560.

Rummel, N., Mullins, D., & Spada, H. (2012). Scripted collaborative learning with the cognitive tutor algebra. *International Journal of Computer-Supported Collaborative Learning*, *7*(2), 307-339.

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