Repairing Disengagement in Collaborative Dialogue for Game-Based Learning

Fernando J. Rodríguez, Natalie D. Kerby, and Kristy Elizabeth Boyer

Department of Computer Science, North Carolina State University, Raleigh, NC 27695
{fjrodri3,ndkerby,keboyer}@ncsu.edu

Abstract. Successfully promoting engagement within learning environments is a subject of increasing attention within the AI in Education community. Evidence is mounting that game-based learning environments hold great potential to engage students, but disengaged behavior is still observed. Devising adaptive strategies to re-engage students in the learning task is a key open research question. Toward that end, this paper examines the collaborative behavior of pairs of middle school students solving game-based computer science problems. We examine the dialogue moves that were used by a more engaged learner to repair a partner's disengagement and consider the implications that these strategies may have for designing collaborative game-based learning environments.

Keywords: Engagement, Collaboration, Dialogue, Game-Based Learning.

1 Introduction

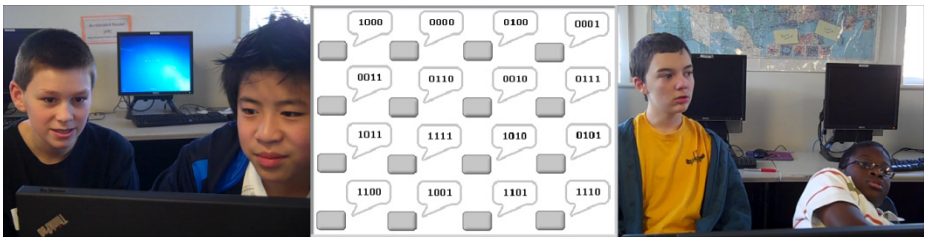
A growing body of empirical findings has revealed the importance of supporting learner engagement. Disengagement has been associated with decreased learning, both overall and with respect to local learning outcomes [1, 2]. Targeted interventions can positively impact engagement, for example, by influencing students to spend more time on subsequent problems [3]. A promising approach to support engagement involves adding game elements to learning environments [4, 5] or creating game-based learning environments with engaging narratives [6]. However, even with these effective systems, some disengaged behaviors are negatively associated with learning, and the relationships between engagement and learning are not fully understood.

Collaboration also holds great promise for supporting engagement and can be combined with game-based learning environments [7]. Results have demonstrated the importance of well-timed help for collaborators [8] and the promise of pedagogical agents that support self-explanation [9]. In the problem-solving domain of computer science, a combination of hints and collaboration support may be particularly helpful [10]. However, many open questions remain. This paper examines the dialogue moves that were used by a more engaged learner to repair a partner's disengagement and considers the implications that these patterns may have for the design of collaborative game-based learning environments.

K. Yacef et al. (Eds.): AIED 2013, LNAI 7926, pp. 807–810, 2013.

2 Description of Study and Data

The corpus was collected within a computer science elective course for middle school students (ages 11 to 14). Participants included 18 males and 2 females, though the female pair was absent on the day the present corpus was collected. (This gender disparity is an intrinsic problem in many technology electives and is an important component of our related research.) Students worked in pairs to solve three game-based tasks using a drag-and-drop visual programming language (Fig. 1).



(a) Engaged pair (b) Software interface (c) Disengaged pair

Fig. 1. Collaborative setup and interface

Students took turns controlling the keyboard and mouse. In computer science education, this is often referred to as *pair programming*: the *driver* actively creates the solution, while the *navigator* provides feedback [11]. Students were asked by a researcher to switch roles every 6 minutes. The maximum allowed time was 40 minutes, with two pairs finishing sooner. Video was recorded using a tripod-mounted camera recording at 640x480 resolution. The nine videos were divided into 5-minute segments to facilitate annotation. Of the total 65 segments, 25 were randomly selected for annotation and serve as the basis for the results presented here (a subset was necessary due to the time requirement of manual annotation, in this case approximately 8 minutes per minute of video). Each segment was annotated for student disengagement by observing for one of three signs of disengagement: posture, gaze, and dialogue. The judge paused the video, annotated the start time of the disengagement event, then continued and annotated the end time, rewinding as needed.

An inter-annotator reliability study was conducted for presence of disengagement, and who (self, partner, or instructor) appeared to facilitate re-engagement. Twelve of the 65 video segments were randomly selected and assigned to two judges, and the tagged segments were subsequently discretized into one-second intervals. The Kappa for disengagement was 0.59 (87.25% agreement). For the events on which both judges agreed that disengagement had occurred, the tag for who facilitated re-engagement resulted in a Kappa of 0.60 (78.57% agreement).

3 Results

Overall, drivers spent an average of 16.4% of their time disengaged (σ=16.6%), compared to 42.6% for navigators (σ=24.1%). Overall, 76.8% of re-engagements were self re-engagements. However, the collaborative role plays an important part: drivers

had an 87.7% probability of self re-engaging, while navigators had a 68.7% probability of self re-engaging. These findings indicate that repairing one's own disengaged state is more challenging for the partner who is not actively at the controls. In order to examine strategies that are effective at repairing disengagement of one's partner, we consider all instances where the driver re-engaged a disengaged navigator through dialogue. There are 22 such instances. Four are questions addressed to the collaborative partner, such as, "OK, now where?" These questions re-engaged the navigator in part because attending to the speaker is a social dialogue norm. Two utterances served as exclamations, e.g., "What the heck?" In these cases, the driver was expressing surprise with an event in the learning environment, which drew the disengaged student's attention back to the task. The remaining utterances were fragments, such as, "Pick up current tile…," though one utterance explicitly reminded the disengaged student about short time remaining, "So we only have a couple of minutes."

To examine these re-engagement events in context, we consider two excerpts (Table 1). In Excerpt A, the navigator gets stuck and raises his hand for help, briefly becoming disengaged before his partner asks for feedback. In Excerpt B, the navigator engages in off-topic dialogue with another team. Meanwhile, the driver makes a plan and then calls for the navigator's attention. These excerpts suggest that within a collaborative game-based learning environment, providing both students with a sense of control is particularly important. To accomplish this goal with a single-computer game-based environment, each student could be provided with different responsibilities and complementary information, even if this additional information is external to the game environment. Additionally, intelligent learning environments may leverage strategic dialogue moves to re-engage disengaged students, a direction that holds particular promise given recent advances in automatic tracking technologies.

Table 1. Dialogue excerpts

Timestamp	Role	Dialogue Excerpt A
19:25	**Navigator:**	OK, if prime, number is prime. Dang!
		[*Navigator notices instructor nearby, raises hand*]
19:34	**Navigator:**	Uh...
Disengaged		[*Navigator looks away from screen, leans back on seat*]
19:38	**Driver:**	OK, now where?
Re-engaged		[*Navigator points at program block*]
19:40	**Navigator:**	Put it there.
		Dialogue Excerpt B
		[Note: students are discussing '@' symbols]
26:01	**Navigator:**	OK, @'s. Do you want more @'s... (inaudible)
26:08	**Driver:**	One two three four five
Disengaged		[*Navigator looks away to talk to another student*]
26:14	**Driver:**	I have an idea. You (taps navigator's shoulder)
Re-engaged		
26:16	**Navigator:**	Me?

4 Conclusion and Future Work

Supporting engagement within a collaborative game-based learning environment may be particularly important for the collaborator who is not at the controls. These learners

may cycle rapidly in and out of attending to the learning environment. Because of strong social norms associated with human dialogue, strategic moves by a partner can serve to re-engage a student. Promising future work includes exploring the extent to which these strategic moves may be leveraged within an adaptive dialogue system. It is also important for future work to examine the duration of engagement and effectiveness of interventions. Additionally, it is important to integrate automated methods of measuring disengagement. Finally, addressing issues of diversity and groupwise differences is an essential direction in order to develop game-based learning environments that support engagement and learning for all students.

Acknowledgements. The authors wish to thank Joseph Grafsgaard and Alexandria Vail for their contributions. This work is supported in part by NSF through grants CNS-1138497 and CNS-1042468. Any opinions, findings, conclusions, or recommendations expressed in this report are those of the participants and do not necessarily represent the official views, opinions, or policy of the National Science Foundation.

References

1. Forbes-Riley, K., Litman, D.: When does disengagement correlate with learning in spoken dialog computer tutoring? In: Biswas, G., Bull, S., Kay, J., Mitrovic, A. (eds.) AIED 2011. LNCS, vol. 6738, pp. 81–89. Springer, Heidelberg (2011)
2. Cocea, M., Hershkovitz, A., Baker, R.: The impact of off-task and gaming behaviors on learning: immediate or aggregate? In: Proceedings of AIED, pp. 507–514 (2009)
3. Arroyo, I., Ferguson, K., Johns, J., Dragon, T., Meheranian, H., Fisher, D., Barto, A., Mahadevan, S., Woolf, B.P.: Repairing Disengagement With Non-Invasive Interventions. In: Proceedings of AIED, pp. 195–202 (2007)
4. Jackson, G.T., Dempsey, K.B., McNamara, D.S.: Short and Long Term Benefits of Enjoyment and Learning within a Serious Game. In: Biswas, G., Bull, S., Kay, J., Mitrovic, A. (eds.) AIED 2011. LNCS, vol. 6738, pp. 139–146. Springer, Heidelberg (2011)
5. Rai, D., Beck, J.E.: Math Learning Environment with Game-Like Elements: An Incremental Approach for Enhancing Student Engagement and Learning Effectiveness. In: Cerri, S.A., Clancey, W.J., Papadourakis, G., Panourgia, K. (eds.) ITS 2012. LNCS, vol. 7315, pp. 90–100. Springer, Heidelberg (2012)
6. Rowe, J., Shores, L., Mott, B., Lester, J.C.: Integrating Learning, Problem Solving, and Engagement in Narrative-Centered Learning Environments. IJAIED, 115–133 (2011)
7. Meluso, A., Zheng, M., Spires, H.A., Lester, J.: Enhancing 5th graders' science content knowledge and self-efficacy through game-based learning. Computers & Education Journal 59, 497–504 (2012)
8. Chaudhuri, S., Kumar, R., Howley, I., Rosé, C.P.: Engaging Collaborative Learners with Helping Agents. In: Proceedings of AIED, pp. 365–272 (2009)
9. Hayashi, Y.: On Pedagogical Effects of Learner-Support Agents in Collaborative Interaction. In: Cerri, S.A., Clancey, W.J., Papadourakis, G., Panourgia, K. (eds.) ITS 2012. LNCS, vol. 7315, pp. 22–32. Springer, Heidelberg (2012)
10. Holland, J., Baghaei, N., Mathews, M., Mitrovic, A.: The Effects of Domain and Collaboration Feedback on Learning in a Collaborative Intelligent Tutoring System. In: Biswas, G., Bull, S., Kay, J., Mitrovic, A. (eds.) AIED 2011. LNCS, vol. 6738, pp. 469–471. Springer, Heidelberg (2011)
11. Nagappan, N., Williams, L., Ferzli, M., Wiebe, E., Miller, C., Balik, S., Yang, K.: Improving the CS1 Experience with Pair Programming. In: Proceedings of the SIGCSE Conference, pp. 359–362 (2003)