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Towards Understanding Collaborative Scientific Inquiry Practices in CSCL Classrooms With In-Game Data

Daeun Hong, Xiaotian Zou, Tianshu Wang, Cindy E. Hmelo-Silver, Krista Glazewski
dh37@iu.edu, xz107@iu.edu, tw17@iu.edu, chmelosi@indiana.edu, glaze@indiana.edu
Indiana University

Suraj Uttamchandani, Adelphi University, suttamchandani@adelphi.edu
Bradford Mott, James Lester, North Carolina State University, bwmott@ncsu.edu, lester@ncsu.edu

Abstract: This paper explores how digital traces within a CSCL classroom can provide evidence to better understand development of students' practices in scientific inquiry. With trace log data, we found several in-game patterns associated with inquiry practices, which implies that trace log data might provide be digital evidence accounting for student learning gains and trajectory of students' scientific inquiry practices within a CSCL classroom.

Introduction and scientific inquiry practices in CSCL

The ill-structured problems and collective goals situated in computer supported collaborative learning (CSCL) require students to engage in intense processes of scientific inquiry and cooperation to solve problems and achieve learning goals (Hmelo-Silver & Barrow, 2008). In such learning context, students engage in collaborative inquiry practices through diverse computer-based activities constructed by interaction within a group. These activities leave digital evidence that can help us understand how students collectively engage in inquiry practices within CSCL settings. To understand and support students' collaborative inquiry practices within CSCL, we need to focus on the conditions for collaborative learning and the processes involved (Stahl et al., 2014). Recently, due to the COVID pandemic, CSCL researchers have often attempted to understand and support students' engagement in computer-based learning environments with limited datasets, which typically have been derived from digital trace data. Such information is essential for timely support contingent on their learning status, which is a critical component of successful scaffolding in CSCL classrooms. In addition, we need to better understand how evidence in trace log data can provide insights into tracing collaborative practices in scientific inquiry.

In CSCL classrooms, inquiry practices can be mediated by computers, and students collaboratively engage with authentic scientific problems as they engage in discursive activity (Saleh et al., 2021). Consistent with sociocultural approaches to learning, recent work on investigating skills in scientific inquiry in CSCL have shifted from analyzing learner's outcomes to characterizing engagement patterns and understanding dynamic processes of collaborative inquiry practices within digital learning settings (Oshima & Hoppe, 2021). However, it is still unclear how computer-mediated activities and underlying processes play a role in advancing student participation in inquiry practices. Because collaborative inquiry practices in CSCL settings are multidimensional, multifaceted, and iterative, it is important to study them through multiple data sources, different conditions, and mixed methods (Stahl et al., 2014) to better understand and support the practices happening in digital contexts. As such, this paper represents an effort to explore identifiable patterns and digital evidence to construct a better understanding of the trajectory of students' scientific inquiry practices during gameplay within a CSCL classroom.

Context and methods

21 groups with 71 seventh graders across three different science classrooms, participated in a collaborative science inquiry game called ECOJOURNEYS, consisting of three quests. The students work collaboratively in teams of three or four to solve an ecosystem problem, 'why are tilapias at a local farm sick?'. After individual investigation phase, students engage in collaborative inquiry activities in each quest. The activities require students to connect knowledge obtained in the game, interpret data provided, generate hypotheses, and reason about scientific claims. Then, they submit a written summary of their takeaways from the activity. In terms of analysis, we chose one group to see how their practices in scientific inquiry changed from the pre- to the post-test compared to other groups. Then, we drew on the group's trace logs during the collaborative activities from Quest 1 to 3 to identify engagement patterns that might have contributed to enhancement of the practices.

Findings

Among all the groups, Group A was chosen due to the completion of all three quests and the second highest learning gain of 10 points. To examine if Group A's scientific inquiry practices have improved in the post-test, we identified specific items where students demonstrated improvement from pre-test to post-test. Students 1, 3,

and 4 within the group, who showed particularly large score increases, due in part on items associated with performance expectations of scientific inquiry practices. In terms of these expectations, the students gained 12, 17, and 16 points, respectively, from pre- to post-test, accounting for most of their learning gains. Indeed, this was manifested in their in-game written responses and answers to open-ended questions, which are associated with the practices. For instance, in Quest 2, Group A collectively analyzed and interpreted data in tables and tried to make sense of differences between dirty and clean fish tanks in terms of dissolved oxygen. Moreover, at the post-test, Student 3 explicitly referenced organized data or a model to explain a causal relationship between dissolved oxygen and fish death whereas the student just typed random characters in the pre-test. In making this interpretation, we treat the random characters typed as an error of omission whereas, at the post-test, Student 3 engaged in relational reasoning about the system. As such, these provide evidence indicating that they have improved their inquiry practices related to those performance expectations.

Based on the Group A's trace log data, we identified the average of the group's active and even participation and time spent on collaborative activities as engagement patterns which may have contributed to improvement in scientific inquiry practices. The level of active participation indicates the number of actions students took, such as referencing information, using evidence, and changing one's stance, during the collaborative inquiry activities. Group A maintained moderate to high level of activeness during the activities across the quests whereas the level of other groups' activeness dropped or stayed low from the beginning. This suggests that the high level of Group A's active participation in the Deduce and TIDE contributed to Group A's learning gains with respect to these practices. The level of even participation represents how evenly students' participation have been distributed throughout the gameplay. It could also imply that the students in Group A collectively committed to their practices in scientific inquiry. Specifically, student 1, 3, and 4 from Group A took turns at leading the activity in Quest 2, 1, and 3, respectively, whereas a few students from other groups dominantly led the collaborative activities across the quests. Indeed, they showed a large increase in post-test scores. Such turn taking at leading a collaborative activity suggests that all students were engaging in inquiry activities. Moreover, Group A spent time on the activities ranging from 224 to 664 seconds throughout the quests, which is moderate to long durations compared to the other groups. Particularly, Group A spent the most time on Quest 1, suggesting that they spent a great deal of effort in engaging and understanding the collaborative inquiry activity up front and thus contributing to high learning gains with low variability. As a result, we found that levels of active and relatively even participation, and duration might be digital evidence accounting for student learning gains in scientific inquiry, which may possibly imply that these should be considered together when analyzing collaborative scientific inquiry processes since one does not always guarantee another.

Future directions

Future studies will further articulate students' engagement in the practices with additional data sources such as in-game chat and video data to provide a fuller picture grounded on more contextual information and explore other proxies of engagement in collaborative scientific inquiry. These will contribute to identifying indices of engagement quality in collaborative inquiry practices and digital evidence indicating development of the scientific inquiry practices.

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