A Real-time Teacher Dashboard for a Game-based Collaborative Inquiry Learning Environment

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Abstract: Ongoing awareness and assessment of students' learning and collaborative activity are fundamental for teacher facilitation. A real-time teacher dashboard helps teachers manage classrooms, attend to group dynamics, and enhance their ability to provide appropriate facilitation. The CRYSTAL ISLAND: ECOJOURNEYS teacher dashboard is a learning analytic dashboard designed to assist teachers in supporting multiple small groups in a collaborative game-based learning environment. The teacher dashboard synthesizes and visualizes information about students' in-game actions and group collaboration to support teachers in interpreting information to make effective instructional decisions. In this demonstration, we will present the teacher dashboard and features, engage participants in viewing representative visualizations generated from simulated student data as well as share our design rationales and experiences.

Introduction

Technology innovation has driven the development of new learning environments and the advancement of new theories. Students learn through the mediation of digital artifacts and technological tools in settings such as computer-supported collaborative learning (CSCL). In such settings, teachers need relevant students' information to understand and support students' learning processes. In recent years, researchers have focused on what teachers need to know about students in CSCL and how to best support teachers in accessing students' information. Orchestration technology has emerged to assist teachers in managing a classroom, facilitating collaborative learning, and promoting inquiry practices (Roschelle et al., 2013). Teacher dashboards are one of the orchestration tools that utilize learning analytics to process large quantities of student data and make data accessible and interpretable to teachers. Dashboards can help teachers make on-the-fly decisions and provide contingent support in classroom contexts. We developed a real-time teacher dashboard to support teachers in managing multiple small groups in a game-based collaborative inquiry environment (Saleh et al., 2020). In this paper, we introduce our teacher dashboard, describe the workflow, and features it incorporates, and discuss our demonstration plan.

Theoretical background

Our teacher dashboard is created to support teachers to facilitate group collaboration in a 3D game-based collaborative inquiry environment titled CRYSTAL ISLAND: ECOJOURNEYS, a new CSCL model that combines problem-based learning (PBL) and game-based learning (Saleh et al., 2020). PBL is a student-driven pedagogical approach that centers around solving ill-structured problems in small groups (Hmelo-Silver, 2004). PBL teachers take the role of facilitator or tutor and focus on students' learning processes rather than providing content knowledge directly to students (Ertmer & Simons, 2006). PBL implementation relies heavily on skilled facilitators and their extensive scaffolding and guidance (Hmelo-Silver et al., 2007). In a traditional PBL classroom, a teacher can walk around a few groups, listen to students' discussions, and provide support as needed. As PBL has been increasingly applied in K-12 education, teachers face the challenges of monitoring many small groups with limited instructional resources (Ertmer & Glazewski, 2015). Although CSCL affords facilitating many groups simultaneously, there is an additional challenge, which is ensuring that the teacher has the right information at the right time in a usable form. A teacher dashboard is one promising tool, which utilizes learning analytics and visualizations to support teachers' instruction (Martinez-Maldonado et al., 2012). Teacher dashboards can help K–12 PBL teachers facilitate PBL inquiry and enhance their facilitation in complex CSCL environments. Prior research on teacher dashboards emphasized learning design, teachers' perspectives, and user experience (e.g., van

Leeuwen et al., 2019). However, few studies provided empirical examples on designing a teacher dashboard for K-12 PBL teachers to facilitate collaborative inquiry. We introduce our teacher dashboard designed to support teachers in facilitating multiple PBL groups by providing collaboration-focused information.

CRYSTAL ISLAND: ECOJOURNEYS

In CRYSTAL ISLAND: ECOJOURNEYS, students work in groups of four to explore a fictionalized island in the Philippines to learn about aquatic systems and collaboratively solve the problem of why tilapia in a local fish farm are sick. First, individual students investigate the problem by interacting with in-game characters and objects to collect information. After this individual investigation, students work as a group to use two in-game tools: (1) the Deduce! App, a tool that allows students to examine the data they have collected and (2) the TIDE brainstorming board to negotiate ideas and vote on whether the information collected is consistent with the explanation provided. Both tools serve as collaborative learning spaces to mediate the group's discussion and necessary PBL inquiry learning (e.g., diagnosis and hypothesis-generation). Throughout the game, students also use an in-game chat tool to support their scientific discussions. In addition, system scaffolds are designed to support students' investigation and collaboration.
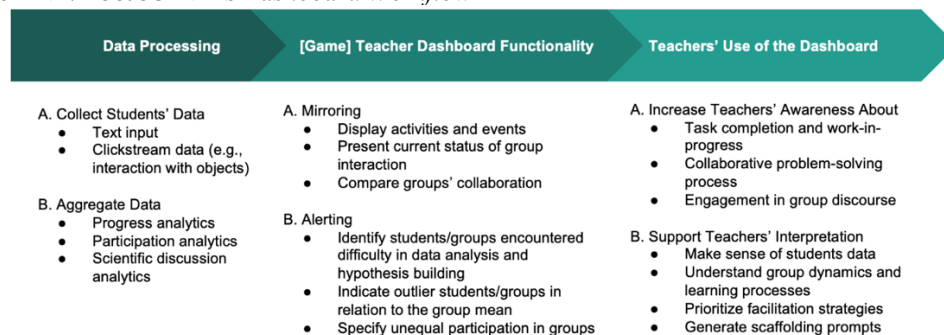
The teacher dashboard

The goal of the teacher dashboard is to support classroom teachers' facilitation of multiple group inquiry processes during collaborative problem-solving. To support this, the teacher dashboard has two core functions, mirroring student information and alerting teachers (van Leeuwen & Rummel, 2019). The mirroring function allows a teacher to assess students' learning activities and continually develop an understanding of students' participation and group processes. For example, a teacher may support groups processes by examining information about groups' contributions in chat and triangulating with groups' progress. If the teacher notices a group has not used the in-game chat but has completed their first round of data analysis, the teacher may decide to help students expand their discussion and foster group accountability by asking open-ended questions and eliciting each students' responses (Hmelo-Silver et al., 2007). The alerts can provide visual indicators to display emergent learning situations that need the teacher's immediate attention and actions. In particular, the alerting feature pinpoints potential facilitating moments. Therefore, alerts signal unpredicted or certain learning situations that need the teacher to provide fine-grained prompts and context-specific scaffolding. By presenting synthesized students' real-time in-game actions, the dashboard provides teachers with concurrent information and alerts to direct teachers' attention to most emergent learning situations.

Once we determined the functions of the dashboard, we further considered how to process in-game student data and how teachers will use the teacher dashboard and take actions to support PBL groups. We present our workflow in Figure 1. Inspired by Verbert's learning analytic model (2013), we considered what kind of student data could raise teachers' awareness and direct their attention to groups' collaborative inquiry processes. Two types of student data will be collected real-time: students' text input and their in-game data while interacting with in-game characters, tools, and objects (e.g., moving a note). The data will be aggregated to present three kinds of analytics, including (1) progress analytics to indicate students' task completion, (2) participation analytics by evaluating students' chat distribution and trace actions, and (3) scientific discussion analytics by providing formative assessment results on students' content understanding and nature of negotiation. All learning analytics will be aggregated at a group level; however, individual data is also available for teachers to examine individuals' learning.

Figure 1
CRYSTAL ISLAND: ECOJOURNEYS *Dashboard Workflow*

We expect that the dashboard will increase teachers' awareness and support their understanding about student learning and collaboration. In our design, a teacher has the agency to interpret the information provided and decide how to use the information. During the decision-making process, the teacher adjusts and adopts different facilitation strategies. If the teacher decides to make a facilitation move by interacting with students, they can walk over to have a conversation with a small group or pause the game for the whole class and provide a mini-lecture or other kinds of support. Alternatively, they may decide not to act immediately and give students more time to negotiate ideas and manage their group process on their own.

Teacher dashboard interface

Figure 2 depicts the whole class dashboard view that displays information on all groups in a table. The whole-class view shows all groups' current learning status and provides formative assessment results on students' participation and scientific discussion. The color-coded progress tab enables teachers to track groups' progress and understand which phase of inquiry students are currently in (the progress analytics). Group participation is compared across groups, based on each group's in-game gameplay and chat actions in each inquiry activity (the participation analytics). Three stars indicate more equal participation among students. Scientific discussion is represented by a composite of completeness and accuracy of student responses, selection of evidence, levels of agreement/disagreement, and the use of sentence starters (the scientific discussion analytics, see Figure 3 for details). For this dimension, more stars imply that students are engaging in higher counts of the desired actions and have more accurate responses. Figure 3 presents a single group view when a teacher decides to enquire more details about the group.

Figure 2
The CRYSTAL ISLAND: ECOJOURNEYS *Teacher Dashboard Prototype: The whole class view*

Group	Progress [Sort]				Participation	Scientific discussion
A	Tutorial	*Investigate*	*Deduce*	*Explain*	★ ★ ★	★ ★ ★
H	Quest 1	*Investigate*	*Deduce*	*Explain*	★ ★ ☆	★ ☆ ☆
B	Quest 1	*Investigate*	*Deduce*	*Explain*	★ ★ ★	★ ★ ☆
D	Quest 1	*Investigate*	*Deduce*	*Explain*	★ ★ ☆	★ ★ ☆
E	Quest 1	*Investigate*	*Deduce*	*Explain*	★ ★ ☆	★ ☆ ☆
G	Quest 1	*Investigate*	*Deduce*	*Explain*	★ ★ ☆	★ ★ ☆
C	Quest 1	*Investigate*	*Deduce*	*Explain*	★ ☆ ☆	★ ★ ★
F	Quest 1	*Investigate*	*Deduce*	*Explain*	★ ★ ☆	★ ★ ☆

Figure 3
CRYSTAL ISLAND: ECOJOURNEYS *Teacher Dashboard Prototype: A single group view*

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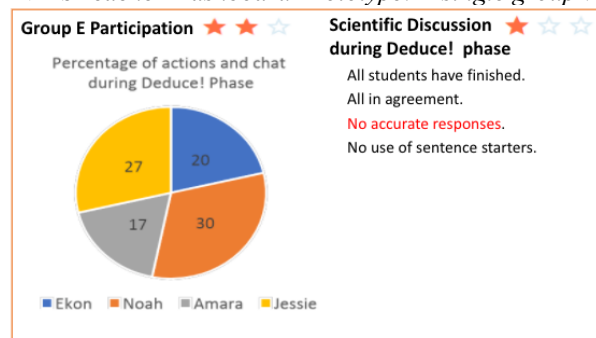
Proposed interactive demo

Our goal is to demonstrate how the dashboard could support teachers to understand students' learning and provide scaffolding in different learning scenarios. We will prepare an online demonstration via Zoom. First, we will introduce the teacher dashboard, demonstrate its basic features, and provide background about the curriculum content and the game interface. Simulated student data will be used to populate the dashboard, which will reflect real-world classroom scenarios and represent group collaboration dynamics. Participants will interact with the teacher dashboard to explore the visualizations and interpret the information. Then, we will assign participants in Zoom breakout rooms to view and discuss the teacher dashboard in small groups. Participants will discuss what they have observed and brainstorm what they might do or not do to provide facilitation if they were teachers. The small room discussion will be facilitated by a researcher from our team. After individual rooms' discussion, participants will rejoin the main room to share their small groups' discussion results. Lastly, we will reveal how we designed each presented collaboration scenario and share our perspectives.

Conclusion and future work

The CRYSTAL ISLAND: ECOJOURNEYS teacher dashboard is a real-time learning analytics dashboard to support teachers to facilitate small PBL groups in a game-based collaborative inquiry learning environment. It helps K-12 PBL teachers to extend their instructional capabilities in managing multiple groups and advance their PBL facilitation by attending to the most needed and emergent learning situations. We will use the final product in the demonstration and engage participants in collaboration to explore the dashboard with simulated student data. We aim to investigate how teachers provide face-to-face scaffolding with the available information in upcoming implementations.

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