# Supporting Collaboration: From Learning Analytics to Teacher Dashboards

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**Abstract:** Designing embedded teacher-support structures within computer-supported collaborative learning environments is key to successful facilitation of group collaboration. Previous work has designed and examined various orchestration tools for teachers facilitating groups of learners, including the integration of a data visualization dashboard for teachers to simultaneously monitor multiple classroom groups. However, few studies have investigated to what extent and which supports are needed to monitor groups while students engage in a game-based collaborative learning environment. This paper proposes a theory-driven design framework for building teacher dashboards and examines the specific functions and design features needed.

**Keywords:** learning analytics, teacher dashboard, collaborative inquiry, game-based learning

## Introduction

Computer-supported collaborative learning environments (CSCL), including game-based learning environments, can generate large amounts of data related to student learning actions and outcomes, which can drive learning analytics. With the emergence of social learning analytics, understanding learning performances has shifted from analyzing performance indicators of individual actions to understanding social activity through interaction and collaboration (Shum & Ferguson, 2012). However, implementing a collaborative game-based learning environment in the classroom is challenging for teachers since they must track how student learning unfolds in multiple small groups.

A promising type of support for teachers is through orchestration tools, such as a teacher dashboard (van Leeuwen, & Rummel, 2019). Dashboards enable teachers to monitor and facilitate collaboration occurring within each group by using an interactive interface, thus allowing teachers to prioritize group intervention (Maldonado, Kay, Yacef, & Schwendimann, 2012). Previous studies have explored teacher dashboard designs and analyzed how teachers use dashboards to support facilitating student collaboration (e.g., Aleven, Xhakaj, Holstein, & McLaren, 2010). However, few studies have examined the design process to determine the functionalities of a teacher dashboard and the types of support teachers need. We propose a theory-driven design framework by integrating a learning analytics model with design principles of teacher orchestration tools to inform the design of teacher dashboards (Verbert et al., 2013; van Leeuwen & Rummel, 2019). We address two research questions: 1) How can we best use student data to understand which indicators are critical in supporting collaboration, and 2) How can these learning analytics drive the design features for a teacher dashboard?

## Theoretical framework

We draw on the learning analytics model proposed by Verbert et al. (2013) and van Leeuwen and Rummel's (2019) framework for teacher orchestration tools to propose design principles for teacher dashboards for CSCL (see figure 1). To answer the first research question, we referenced the model proposed by Verbert et al. (2013) who identified key steps for applying a model of learning analytics. This conceptual framework of the learning analytics process model consists of the initial stage of *Awareness*, the stages of *(Self-)Reflection* and *Sensemaking*, and the final stage of *Impact*. Each stage of the model has a different focus. Data is considered the only factor in the Awareness stage and can be presented as visualizations. Understanding student data is the focus of this study.

To answer the second research question, we draw on van Leeuwen and Rummel's (2019) analysis of teacher orchestration tools to understand design features for teacher dashboards. Their analysis suggests specific functions of

 

learning analytics that target teacher orchestration, including mirroring, alerting, and advising. Mirroring refers to the presentation of information about students' learning activities, whereas the alerting function helps teachers act by setting priorities on particular events, and the advising function provides recommendations for facilitation. In our collaborative game-based learning environment, the teacher dashboard will combine the functions of mirroring, alerting and advising, which are generated from group interactions during in-game collaborative brainstorming sessions. The mixed functions can support teachers throughout their facilitation practice by tracking students' collaboration process (Mirroring), enable teachers to select priorities for when to intervene (Alerting) and facilitate with appropriate types of prompts (Advising). Identifying these functions, the specification of the design features is essential before proceeding to the design phase and implementation phase. This framework guides our learning analytics design in a collaborative game-based learning environment integrated with problem-based learning (PBL). Below we describe the development of our game-based learning environment that draws on problem-based learning and highlight how the learning analytics derived from student interaction can support the development of an interactive teacher dashboard.

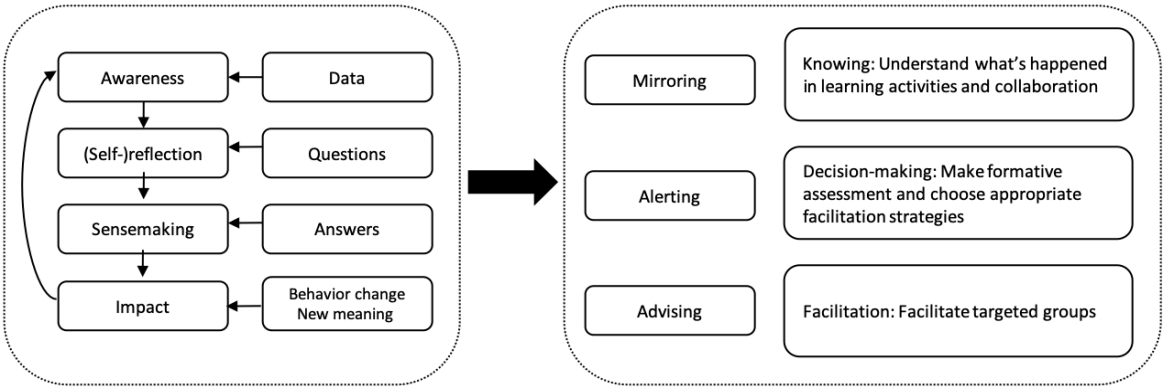


Figure 1. A proposed design for a teacher orchestration tool based on student learning analytics.

## A collaborative game-based learning environment

In our game-based learning environment, students visit an island in the Philippines as part of a field trip to learn about aquatic systems, only to discover that the fish in the local hatchery are sick. Students work in groups of four and are enlisted as helpers to support the local fish technician and engage in three phases of inquiry cycle from collecting data individually to joining a shared workplace to discuss ideas and generate hypotheses with their group. Students explore various perspectives by interacting with different in-game characters and collecting information. After collecting data, students use a collaborative learning space, the in-game PBL brainstorming board. At the brainstorming board, students can share notes they have collected by dragging them to the board, negotiate ideas by using the in-game chat, and voting on the relevance of the notes to the associated topic. The board is organized into five columns that represent components in the system that may explain why the fish are sick. Students need to move notes from their personal notebook to the shared board into columns representing a possible hypothesis. The notes are expandable for students to open and read. Students then vote for each note regarding its relevance to a particular column. In-game chat supports students to maintain communication, develop understanding and make decisions as a group.

## Method

Forty-five 6th-grade students (23 males, 22 females) from a rural midwestern school engaged with the game-based learning activities over nine 55-minute classroom sessions for two weeks. The teacher assigned students into groups of 4-5 and each group was assisted by a human facilitator. The facilitators were trained in PBL and interacted with students via the in-game chat. The facilitator supported students' discussion around the brainstorming board activities. A simple facilitator interface was provided in the game for the facilitator to select appropriate prompts as needed to support group discussions.

To unpack the relationship between the learning analytic process model and the teacher dashboard design, we examined students' chat as the main student learning analytic and accordingly coded the facilitator prompts in

students' chat. Focusing on facilitator prompts allowed us to conduct further interaction analysis to understand how group collaboration unfolded according to the learning analytic process model (Hall & Stevens, 2016). The chat data analysis for this study focused on students' actions of moving notes and voting actions at the brainstorming board, which was the main collaborative learning space in the game. The chat data analysis allowed us to understand what data was needed in the teacher dashboard. In particular, we focused on facilitation prompts to understand the instructional practice and facilitation strategies the facilitator used to support students' discussion. We assumed that these moves could be embedded in the teacher dashboard, especially as advice for teachers.

## Findings

We present a case study here to illustrate how facilitators' prompts supported students and further discuss how these different types of prompts could be fed into a teacher dashboard. The three inquiry phases in the game progress in a similar manner with the differences being more notes on relations among components and processes as students move to the next phase. The iterative inquiry cycles encourage students to narrow down the options of hypotheses and focus on the mechanisms in the ecosystem. For this case study, we chose the group with the most utterances from both students and facilitators and that represented varied situations that we have seen in other groups.

We saw that many prompts from the facilitator were used to orient students to engage in tasks at the beginning of the brainstorming conversation. We noticed that the facilitator spent 4 minutes on the first session and 3 minutes on the second session to direct students to share notes and vote on the relevance for each note as well as remind students to stay on topic and be respectful for each other's ideas. To generate and maintain productive discourse, it is critical for teachers to check students' understanding of their learning activities and help students to establish norms to participate in collaboration (Michaels et al., 2010). We anticipate that the mirroring function in a teacher dashboard will serve the purpose of summarizing students' learning activities and notify teachers about students' up-to-date status of their learning process. It will also keep teachers informed by accessing group profiles of collaborative inquiry and developing a holistic view of group performance.

We also found that students' conversations were interrupted by off-topic words, symbols, and emojis throughout all sessions. For example, in the first 10 minutes of the third session, the group generated 82 utterances (lines of chat) in total and 19 of them were irrelevant utterances, including emojis and off-topic words. All of those utterances were from one student, who we will call Nathan. For the rest of this session, Nathan continued to send similar text messages and did not provide substantive contributions to the group chat, such as sharing and discussing ideas. During the session, the other three students sent 9 lines of chat in total to ask him to stop the off-topic talk and focus on the topic, for example, "stay on topic" or "no goofing around." Notably, the facilitator was the last person in the group to regulate Nathan's behavior near the end of the session. Nathan's chat behavior illustrates the necessity of sending alerts to the teacher via a teacher dashboard to detect the anomaly and suggest an intervention. More importantly the dashboard could enable the teacher to pause students' discussion, ask students to discuss norms for good collaboration and reflect on their behaviors. Early and timely facilitation can prevent further disruption of productive discourse. The design feature on the alerting function should enable the teachers to select targeted groups or students and send messages to the group or have a face-to-face conversation.

The excerpt below demonstrates how the facilitator elicited understanding and prompted higher-order thinking. Charlie posed a question about the issues (Line 1), and this question was asked after students have agreed and removed two issues from the board (water temperature and space), which were not the causes of the dead fish supported by evidence. Here Charlie tried to check his understanding of the relations between the issues and the problem. The facilitator answered (Line 2) and emphasized the goal of problem solving (Line 4). Ashley followed up and stated that one component specifically plays a role in the problem, but all of the issues were connected to the problem (Line 6). Then the facilitator asked for agreement (Lines 8) and received students' responses (Lines 9 and 10). In the end, the facilitator summarized and marked students shared understanding (Line 11), and then students agreed (Lines 12 to 16). In self-directed collaborative learning among students, without facilitators' confirmation, elaboration and regulation, students might feel uncertain or confused and have difficulty moving on. Thus, providing recommendations for teachers to make contingent support and advance students' learning is important. The design of the dashboard should include a list of recommendations on specific dimensions of collaborative inquiry and enable teachers to choose the most relevant.

Excerpt 1: In-game facilitation to advance student discussion

| | | |
|---|---|---|
| 1 | Charlie | Are all the things on the board issues or are they possible issues? |
| 2 | Facilitator | They are all possible issues. |
| 3 | Charlie | Ok. |
| 4 | Facilitator | The goal eventually is to figure out why the fish are sick and what info is useful for solving the problem. |
| 5 | Charlie | Ok, so we are narrowing down. |
| 6 | Ashley | Yeah, I think everything but the cyanobacteria for now is relevant and plays a part in the issue. |
| 7 | Bianca | Yeah, I agree. |
| 8 | Facilitator | Do others agree? |
| 9 | Bianca | I do. |
| 10 | Dylan | Yeah. |
| 11 | Facilitator | So, we're thinking that air, water quality, and food are all playing a part in the fish being sick. |
| 12 | Dylan | I do. |
| 13 | Ashley | Yep. |
| 14 | Dylan | Yes. |
| 15 | Bianca | Yep. |
| 16 | Charlie | Yeah. |

## Conclusion

Making student's collaboration explicit and visible is critical to support teachers in CSCL environments. A teacher dashboard is one such tool that supports this goal. In this study, we investigated students' learning analytics to understand how their collaboration was mediated by a shared learning space and identified what design features should be included in a teacher dashboard. In our next iteration, we will implement the resulting design in classrooms, examine the actual interaction between teachers and dashboards, and examine how the teacher dashboard assists teachers in monitoring and supporting multiple groups of students at the same time.

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