Examining the Use of a Teacher Alerting Dashboard During Remote Learning

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Abstract. Remote learning in response to the COVID-19 pandemic has introduced many challenges for educators. It is important to consider how AI technologies can be leveraged to support educators and, in turn, help students learn in remote settings. In this paper, we present the results of a mixed-methods study that examined how teachers used a dashboard with real-time alerts during remote learning. Specifically, three high school teachers held remote synchronous classes and received alerts in the dashboard about students' difficulties on scientific inquiry practices while students conducted virtual lab investigations in an intelligent tutoring system. Quantitative analyses revealed that students significantly improved across a majority of inquiry practices during remote use of the technologies. Additionally, through qualitative analyses of the transcribed audio data, we identified five trends related to dashboard use in a remote setting, including three reflecting effective implementations of dashboard features and two reflecting the limitations of dashboard use. Implications regarding the design of dashboards for use across varying contexts are discussed.

Keywords: Dashboard · Intelligent tutoring system · Remote learning

1 Introduction

The COVID-19 pandemic has impacted educators and students around the world, resulting in a shift in instructional contexts and methods [19]. As such, teachers require technologies that can help them to overcome common challenges with teaching remotely (e.g., assessing and monitoring student learning [2, 6, 8, 16]), particularly in STEM contexts. Fortunately, several innovative technologies exist for teacher monitoring in STEM [3], such as learning analytics dashboards [20] that provide educators with data on student progress based on an open learning model (OLM; [4, 5]). Several dashboards align with STEM learning environments (e.g., Lumilo [11, 12], Snappet [13], HOWARD [14], MTFeedback [17]). Researchers, however, have not explored the use of these technologies in remote synchronous contexts and few dashboards provide real-time alerts to teachers on students' difficulties on complex STEM practices.

In our recent work, we developed Inq-Blotter, a teacher dashboard that provides real-time alerts about students' difficulties on inquiry practices exhibited in a virtual science

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lab in the Inquiry Intelligent Tutoring System, Inq-ITS [9, 10]. Recent studies [1, 15] have shown the technologies to be effective in supporting student learning of inquiry practices, but researchers have yet to investigate their use in a remote synchronous setting. In the present paper, we conducted a mixed-methods study to answer the following research questions (RQs): RQ1) Do students improve on inquiry practices when Inq-Blotter is used with Inq-ITS in a remote synchronous setting? and RQ2) What common trends appear in terms of *how* Inq-Blotter was used in a remote synchronous setting?

2 Methods

The participants in the present study included three high school STEM teachers and their students (N = 121 students) from three high schools in the northeastern United States. All teachers used Inq-Blotter synchronously while their students completed an Inq-ITS lab remotely during a class period between December 2020 and January 2021.

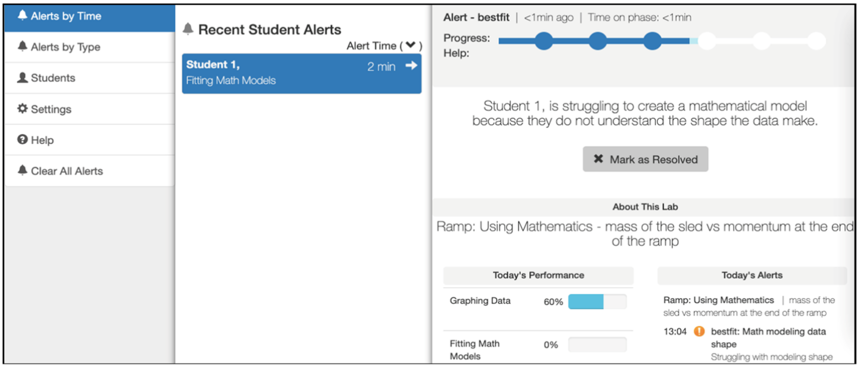

Fig. 1. Screenshot of Inq-Blotter with an alert for the Building Models stage.

In terms of materials, the *Inq-ITS* investigation that students completed in the present study was the Ramp: Using Mathematics virtual lab set (i.e., Ramp Lab). In the lab, students complete three investigations to identify the mathematical relationships between variables related to a sled going down a ramp. Each lab investigation includes six stages that align to inquiry practices including: 1) Hypothesizing (making a hypothesis), 2) Collecting Data (running experimental trials using a simulation), 3) Graphing Data (creating a graph), and 4) Building Models (selecting the type of mathematical relationship in the graph and creating a best-fit line). Students then summarize their findings. *Inq-Blotter* provides real-time alerts to teachers on students' difficulties and progress within Inq-ITS virtual labs (see Fig. 1). The alerts are triggered based on educational data-mined and knowledge-engineered scoring algorithms in Inq-ITS in stages 1–4 (see Measures section for further details). The individual student alerts that appear contain details on the specific difficulty a student is having with a practice, as well as other contextual information (see Fig. 1). There are also "Whole Class" alerts that appear when more than 50% of the class is struggling with a practice and "Slow Progress" alerts when a student has been on a stage for more than 5 min.

For the measures, *log data from Inq-ITS* were used to capture student performance. In particular, students' competencies with the science inquiry practices in stages 1–4 were automatically scored (from 0 to 1) by educational data-mined and knowledge-engineered algorithms as described in prior work [10]. *Log data from Inq-Blotter* were used by researchers to identify the types of alerts viewed by the teacher, the students who were helped by a teacher in response to the dashboard, and the inquiry practices on which they were helped. *Audio-recordings* from each of the remote dashboard implementations were transcribed and timestamped. The transcribed audio data was segmented by speaker turn and only segmented transcripts related to dashboard use were included in the analyses ($N = 49$ transcript segments). The data from Inq-ITS, Inq-Blotter, and transcript segments were triangulated based on timestamps for analyses.

In terms of the analyses, mixed-methods were used to examine student performance as well as to understand *how* the dashboard was used in the remote synchronous context. To answer RQ1 (Do students improve on inquiry practices when Inq-Blotter is used with Inq-ITS in a remote synchronous setting?), a Repeated Measures Multivariate Analysis of Variance (RM MANOVA; with an alpha = .05) and follow-up comparisons (with a corrected alpha = .0125 (.05/4; [18]) were used to explore performance across activities for students who completed all three lab activities ($N = 86$ students). Qualitative analyses were used to answer RQ2 (What common trends appear in terms of *how* Inq-Blotter was used in a remote synchronous setting?). Five trends were defined (see Table 2), reviewed, and applied to transcripts (researchers reached 90% agreement).

3 Results

First, to answer RQ1, an RM MANOVA was used to explore whether there was a difference in student performance across activities. Results of the RM MANOVA revealed that the overall model was significant with differences in overall inquiry performance found across activities, $F(8, 78) = 7.68$, $p < .001$, $n^2 = .44$ (see Table 1). There were also significant within-subjects main effects found for each of the inquiry practices with students improving from the first to third activity for all practices except Applying Equations (which is a particularly difficult practice [7]; see Table 1).

Table 1. Average inquiry practice scores across activities and results of RM MANOVA.

Practice stage	Lab 1 *M* (*SD*)	Lab 2 *M* (*SD*)	Lab 3 *M* (*SD*)	Within-subjects effects
Hypothesizing	.83 (.31)	.95 (.16)	.97 (.14)	$F(2, 170) = 10.99$, $p < .001$
Collecting data	.90 (.23)	.95 (.16)	.97 (.15)	$F(2, 170) = 9.34$, $p < .001$
Graphing data	.72 (.24)	.80 (.24)	.83 (.22)	$F(2, 170) = 9.68$, $p < .001$
Building models	.62 (.37)	.88 (.26)	.69 (.26)	$F(2, 170) = 14.56$, $p < .001$
Overall	**.77 (.19)**	**.90 (.14)**	**.86 (.16)**	$\mathbf{F(8, 78) = 7.68, p < .001}$

To answer RQ2, we explored trends that reflected effective use of the design features of the dashboard in the remote synchronous context. The most commonly occurring trend across the transcribed audio segments was that teachers used the dashboard to Identify Student Difficulties followed by using the dashboard to Identify Trends in Class Data and Identify Inactive Students (see Table 2). We also identified two trends related to limitations of remote dashboard use including Communication Limitations and General Technical Challenges (see Table 2), which could be addressed in future design iterations to better support synchronous remote instruction.

Table 2. Trends in dashboard use during remote learning, definitions, and examples.

Category	Trend	Definition	Example (Segment ID)
Effective Use of Dashboard Features	Identifying Student Difficulties ($N = 18$)	Individual support to a student on an inquiry practice	T: I am seeing that you are probably having some trouble graphing? And you only have three data points…You must at the very minimum have 5 so you can actually see how the data… line up…(52)
	Identifying Trends in Class Data ($N = 12$)	Class support based on pattern across multiple students' inquiry performance	T: I see a whole bunch of them having trouble with the modeling because they don't have enough data points to see the fit … (28)
	Identifying Inactive Students ($N = 7$)	Addressing students working on the wrong lab or not actively completing the lab	T: Flower growth?....Well I think one of my student groups is working on the flower lab instead of this [Ramp] one (18)
Limitations	Communication Limitations ($N = 15$)	Limitation related to modes of communication during remote dashboard use	T: This would be so much easier if I could take a glance over their shoulder. It takes so much extra time to get them to share everything to take a look… (17)
	General Technical Challenges ($N = 11$)	Internet, computer, or meeting programs interfering with dashboard use	T: I don't understand, sometimes [the meeting] breakout room allows me to move them to main session and sometimes they don't… so I cannot help her…(67)

4 Discussion

Remote learning involves a number of challenges for instructors [2, 6, 8, 16]. This study provides initial evidence that these challenges can be addressed by carefully-designed alerting dashboards that enable teachers to monitor and support students during synchronous instruction. Quantitative results showed that students improved across activities for the majority of science practices in Inq-ITS when teachers used Inq-Blotter remotely. Additionally, qualitative analyses further demonstrated *how* Inq-Blotter alerts and features enabled teacher monitoring within a remote synchronous context. Future designs might consider integrating a functionality to directly view student work or communicate through the dashboard to address some of the challenges identified. Additional studies are needed with a greater number of participants to better understand how these findings generalize across contexts . Overall, these initial implementation studies are essential for informing the iterative design of technologies to meet the needs of teachers and students across contexts.

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