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Abstract

In this study, we examined teachers' remote use of a science dashboard, Inq-Blotter, through discourse analyses and students' corresponding inquiry performance in Inq-ITS. Specifically, Epistemic Network Analyses were applied to compare patterns of support elicited by Inq-Blotter when students improved versus did not improve on inquiry in Inq-ITS. Analyses revealed significant differences in teacher support patterns in relation to student improvement. These results demonstrate how dashboards can support science discourse and learning during remote instruction.

Keywords: Dashboard, Epistemic Network Analysis, Intelligent Tutoring System, Remote Learning

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Prior to the COVID-19 pandemic, there was a need for teacher tools to assess and guide students on critical science practices (NGSS, 2013), which are difficult to capture using traditional assessments (Pruitt, 2014). Remote learning due to COVID-19 has further magnified these assessment challenges and introduced other issues, such as limited opportunities for one-to-one interactions with students in real-time (Marshall et al., 2020). Fortunately, technologies such as online student environments with accompanying dashboards for science (e.g., HOWARD, Lajoie et al., 2020; SAIL Smart Space tablet tool, Tissenbaum & Slotta, 2019) enable teachers to monitor student progress and provide personalized feedback to students. To date, however, many dashboards are not instrumented to assess and report on students' complex inquiry practice competencies as outlined by the NGSS (2013). Furthermore, the benefits of dashboards have not been examined in the context of remote synchronous classroom settings.

The present study addresses both of the aforementioned issues through an examination of the remote use of the Inq-Blotter dashboard. Inq-Blotter provides real-time alerts to teachers as students complete virtual labs in an intelligent tutoring system, Inq-ITS. Inq-Blotter has effectively guided teacher support in in-person contexts (Dickler et al., 2021), and alerts have been updated to include additional Teacher Inquiry Practice Supports (i.e., TIPS) to promote higher-level inquiry support (Adair et al., 2020). In the present study, we examine the impact of Inq-Blotter with TIPS in a remote synchronous setting, which has been unaddressed in our work to date. Specifically, we tested the use of Inq-Blotter alerts with TIPS within synchronous remote high school classrooms in order to identify whether teacher support (as facilitated by inquiry practice alerts) was associated with student improvement on their next inquiry opportunity (on the practice on which they were helped). Additionally, we examined the patterns in teacher discursive support using Epistemic Network Analyses (ENA; Shaffer et al., 2016) to understand how the alerts with TIPS were used remotely.

Methods

Participants

The participants in the present study included three high school science teachers (from three different schools in the northeastern United States) and their students (N = 106 students).

Materials and Study Design

All students were assigned an Inq-ITS tutorial for homework that they completed online prior to data collection. Data collection occurred remotely via a virtual meeting platform during the regularly scheduled synchronous science class periods in January and February of 2021. During the class period, students completed the Inq-ITS Ramp with Graphing High School lab to explore the relationship between variables related to a sled going down a ramp (i.e., ramp heights, sled masses, ramp roughness). This lab set involved three investigation activities with stages aligned to the NGSS (2013) inquiry practices, including: **asking questions/hypothesizing** about a scientific phenomenon, **carrying out an investigation** using a simulation, **constructing a graph** of the phenomenon, and **applying equations** to create a best-fit line on the graph (see Figure 1).

While students worked in Inq-ITS, the teachers used Inq-Blotter to monitor students' progress. Inq-Blotter provided teachers with real-time alerts on students' specific difficulties based on automated scoring (see Measures) of the inquiry practice stages shown in Figure 1. Within each alert, teachers could click through four levels of suggestions for how to guide students on the practice of difficulty (see Figure 2), including: orienting TIPS (i.e., helping direct student attention towards the practice of difficulty), conceptual TIPS (i.e., explaining key components of the practice of difficulty), procedural TIPS (i.e., outlining the steps involved in the practice of difficulty), and instrumental support (i.e., telling the student the exact steps needed to move forward). All interactions between teachers and students in response to an alert were audio-recorded and timestamped by a researcher who attended the virtual class sessions.

Figure 1

Screenshots of inquiry practice stages in [ITS]

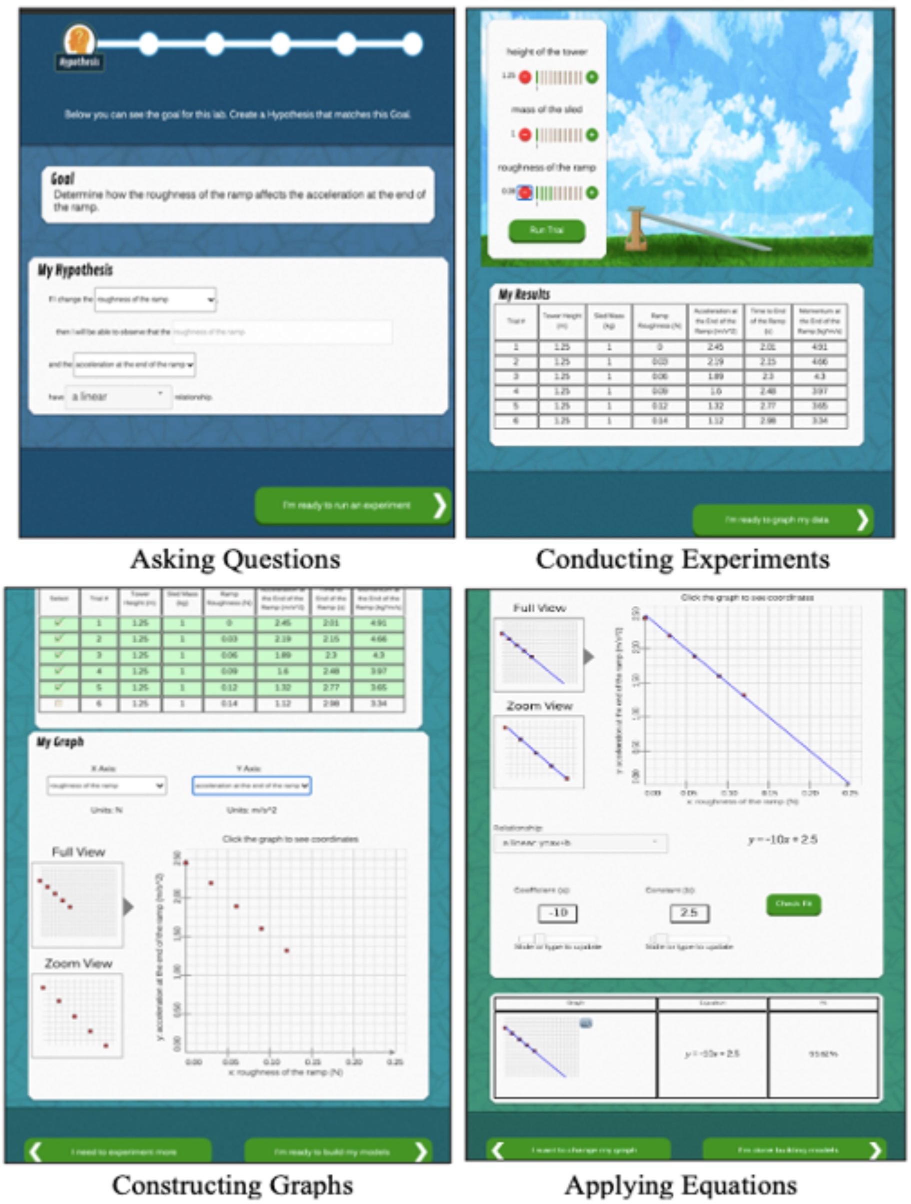
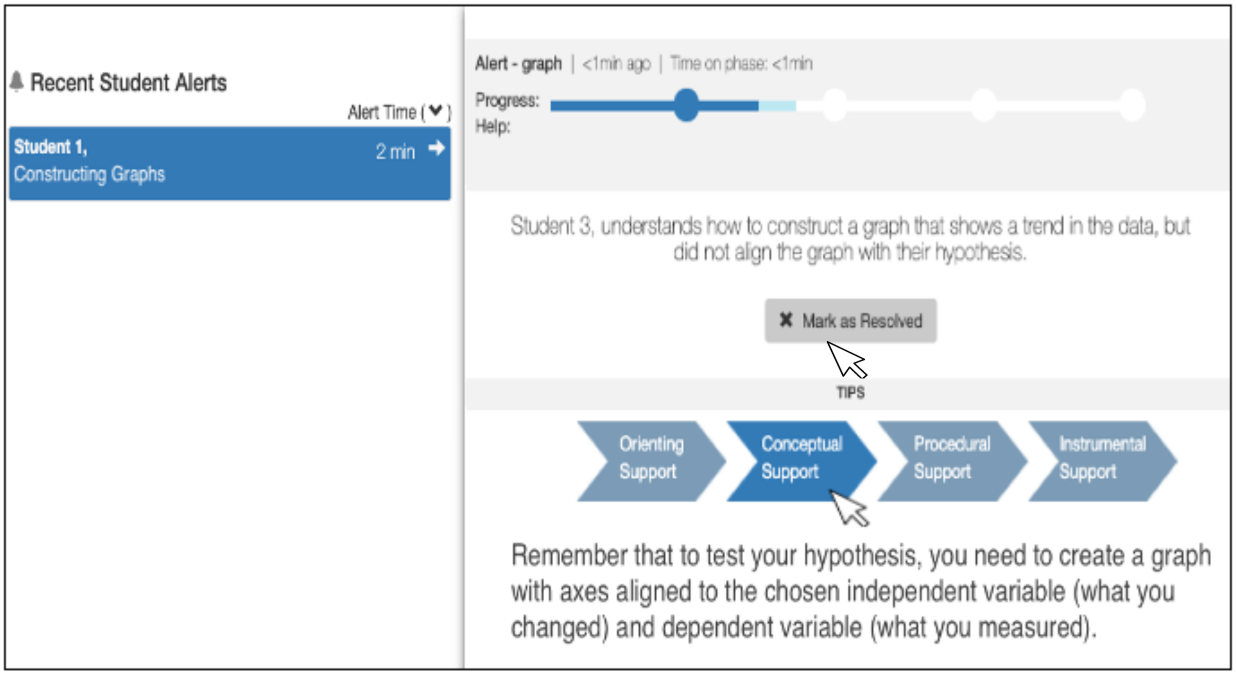


Figure 2

Screenshot of [Dashboard] with inquiry support prompts



Measures

Student performance on the four inquiry practice stages in Inq-ITS was automatically scored from 0-1 using previously validated knowledge-engineered and educational data-mined algorithms (Gobert et al., 2013, 2018). Students' scores on the inquiry practice stages in each of the three lab activities were used for analyses.

Teacher actions in Inq-Blotter (e.g., selecting an alert, clicking on a detailed teacher support prompt) were automatically logged and timestamped. Logs also included the contextual information from the alerts and prompts.

Additionally, the timestamped audio-recordings of teacher-student interactions generated by an Inq-Blotter alert were transcribed and anonymized (N = 52 recordings). Each transcript was segmented based on speaker turn, with only the teacher turns being used for analyses (N = 64 teacher turns). All teacher turns were coded by one researcher for the presence of teacher discursive supports using the scheme applied in prior studies (see Table 1; Dickler et al., 2020). One teacher turn could be coded as representing multiple types of support. Two additional researchers each scored half of the turns and agreed on 86% of codes. Disagreements were discussed and agreed upon codes were used for analyses.

Table 1

Teacher discursive support codes and examples for an applying equations alert.

Code	Description	Examples
Orienting Scaffold	Directs the students' attention towards a practice	"Looking at the data on your graph. What is the trend in the data?"
Conceptual Scaffold	Explains components involved in an inquiry practice to a student	"So the goal is to choose a relationship or a mathematical equation that represents the trend in the data.…you can click on the relationship dropdown menu to see what each mathematical relationship looks like."
Procedural Scaffold	Tells the students the steps involved in an inquiry practice	"So you should always have at least 5 data points…and the more the better so you can actually see what the graph's gonna look like."
Instrumental Scaffold	Tells the student exactly what to do/click to move forward on an inquiry practice	"So just keep sliding around [the coefficient] until you find the right fit."
Content Comment	Tells or asks the student about some scientific content	"…if I change the height, the time's gonna change right?"
Evaluative Comment	Makes a comment regarding whether something is right, wrong, correct, or has an issue	"It looks like you are having trouble with your line."

Analyses

The data from Inq-Blotter were triangulated with the transcribed audio data using timestamps to identify the students who were helped by a teacher using Inq-Blotter. We then extracted inquiry practice scores for all students helped by a teacher (on the practice on which they were helped) who went on to complete a second activity (N = 35 students). Paired samples t-tests were used to identify if students significantly improved after receiving teacher help.

Additionally, log data were triangulated with the coded audio transcriptions to build the epistemic networks (Shaffer et al., 2016). In particular, separate networks were created for the teacher support associated with student improvement versus no student improvement. The six discursive support codes were used as the nodes in each network and the unit of analysis was each interaction elicited by an alert. The networks were quantitatively compared using t-tests and qualitatively compared using the subtracted network (i.e., the difference in weighted connections between networks).

Results

First, we examined whether students who were helped by a teacher based on an alert significantly improved on the practice on which they were helped (i.e., comparing their score on the practice in the activity prior to being helped to their score on that practice in their next activity after being helped). Descriptive statistics revealed that the majority of students who were helped by a teacher using Inq-Blotter improved (71% of students; see Table 2), which aligns with results from prior in-person studies (Dickler et al., 2021). The results of the paired-samples t-test collapsed across practices revealed that students significantly improved from prior ($M = .35$, $SD = .30$) to after being helped by a teacher using Inq-Blotter ($M = .83$, $SD = .29$), $t(34) = -7.48$, $p < .001$, $d = 1.62$. While the majority of students significantly improved after receiving teacher support based on Inq-Blotter, it is important to examine whether there were differences in teachers' discourse that may have facilitated improvement and, in turn, iterate on the design of the dashboard's alerts in order to support these forms of discourse remotely.

To compare the patterns in teachers' discursive supports when students improved (N = 25 interactions) to when they did not (N = 10 interactions), ENA (Shaffer et al., 2016) was used. Results of the ENA revealed a significant difference in the pattern of teacher supports associated with student improvement ($M = .19$, $SD = .45$; see left of Figure 3) versus no improvement ($M = -.48$, $SD = .30$; see right of Figure 3), $t(34) = -7.48$, $p < .001$, $d = 1.62$. An examination of the subtracted network (see Figure 4) revealed that the alerts with TIPS seemed to successfully elicit higher-level conceptual, procedural, and evaluative supports in cases where students showed improvement. On the other hand, teachers provided more instrumental and content support in cases where students did *not* improve.

Table 2

Student performance on inquiry after receiving teacher help elicited by [Dashboard]

Inquiry Practice Stage	Percent of Students Improved	Score Prior to Teacher Help	Score After Teacher Help
Asking Questions	71% (5/7)	.46	.93
Carrying out an Investigation	71% (5/7)	.28	.89
Constructing Graphs	60% (6/10	.55	.78
Applying Equations	82% (9/11)	.17	.78
OVERALL	**71% (25/35)**	**.35**	**.83**

Figure 3

ENA for support patterns associated with improvement (right) versus no improvement (left)

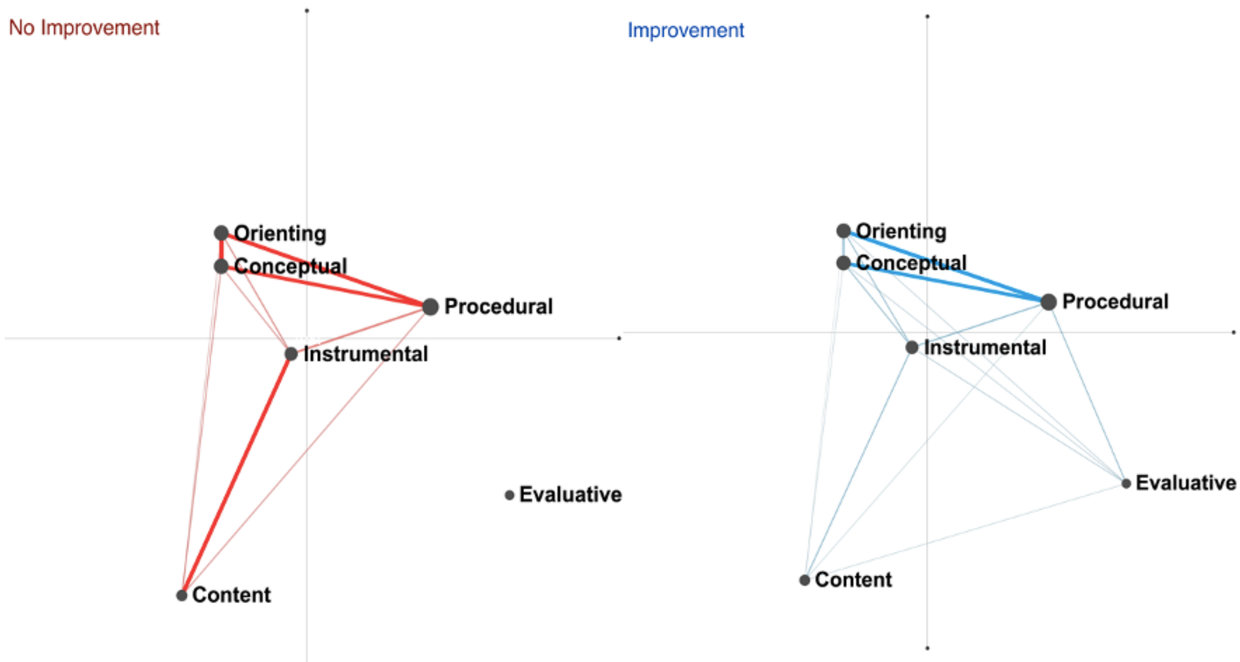
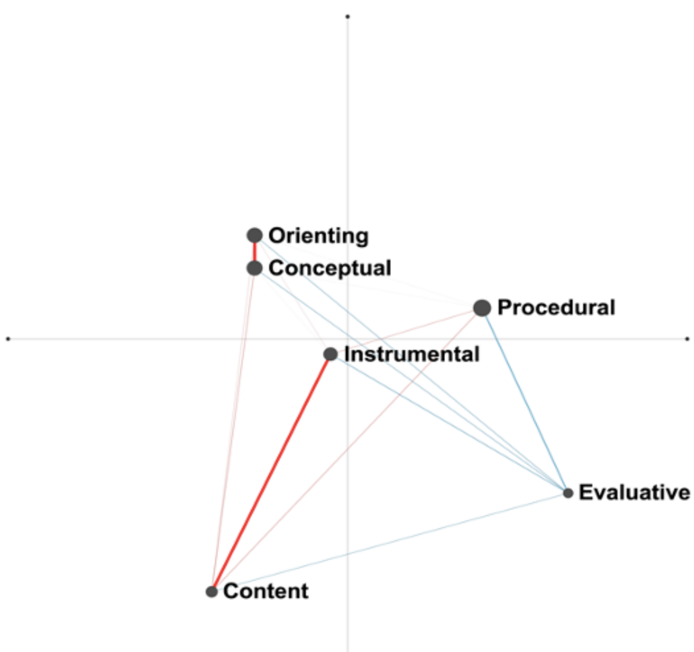


Figure 4

Subtracted ENA for when students improved versus did not improve



Discussion

The technologies in the present study provide a solution critical for science teachers because they enable remote monitoring of students' inquiry competencies, which are challenging to capture using traditional assessments across settings (Pruitt, 2014); the needs for fine-grained assessment and monitoring tools are greatly amplified due to COVID. The findings of this study revealed that Inq-Blotter was successful in guiding remote teacher support associated with student improvement on inquiry practice difficulties in Inq-ITS. While these findings are exploratory given the small sample size, this work serves as evidence of the potential of dashboards to guide meaningful teacher discourse and student learning remotely. In particular, Inq-Blotter provided fine-grained, targeted assessment data that promoted high-level teacher support as captured through a rich analysis of the discourse. Future studies will explore the use of the dashboard with a greater number of participants as well as more deeply examine the decision making processes of teachers in regards to the types of supports provided in response to alerts.

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