Effects of a Dashboard for an Intelligent Tutoring System on Teacher Knowledge, Lesson Plans and Class Sessions

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Abstract. Even though Intelligent Tutoring Systems (ITS) have been shown to help students learn, little research has investigated how a dashboard could help teachers help their students. In this paper, we explore how a dashboard prototype designed for an ITS affects teachers' knowledge about their students, their classroom lesson plans and class sessions. We conducted a quasi-experimental classroom study with 5 middle school teachers and 8 classes. We found that the dashboard influences what teachers know about their students, which in turn influences the lesson plans they prepare, which then guides what teachers cover in a class session. We believe this is the first study that explores how a dashboard for an ITS affects teacher's knowledge, decision-making and actions in the classroom.

Keywords: Intelligent Tutoring Systems · Dashboard · Data-driven instruction · Teachers' use of data · Learning analytics

1 Introduction

Although it is by now well established that Intelligent Tutoring Systems (ITS) can enhance student learning [4], ITSs are rarely designed for teachers or with teachers in mind. For example, when a student is not progressing well in the ITS, the teacher might be able to help the student move forward. A dashboard could alert the teacher to such a situation, and more generally, a dashboard could inform the teacher about the students' abilities and performance in the ITS. Almost no work has focused on creating and studying a teacher dashboard for an ITS. Much research focuses on evaluating dashboards for other types of learning technologies, and on studying whether dashboards are useful to teachers [6, 7]. Further, while many dashboards are used in real-time, during a class session, teachers might also use a dashboard in other scenarios, such as when preparing for a class session. Kelly et al. (2013) studied how a teacher used a report on students' performance in a web-based homework system to decide what parts of the homework to review in class, with positive effects [3]. Our study is different in that it uses a fully featured rather than a simplified ITS, involves more teachers and students, a different dashboard design and use scenario (namely, for lesson planning rather than homework review), and different data analysis approach.

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In this work, we present our findings from a quasi-experimental classroom study in which 5 middle school teachers, with 8 classes in total, used a dashboard prototype for an ITS. We investigate the effect of the dashboard on teacher practices, and we focus on a scenario in which teachers use a dashboard with analytics from an ITS to prepare for, and then conduct, a class session following sessions during which students worked with the ITS.

2 Methodology

2.1 Formative Evaluation of the Dashboard in the Classroom

We conducted a quasi-experimental study to address the research question: *How does the dashboard affect teacher practices in the classroom?* The study is part of our user-centered design process for Luna, a high-fidelity dashboard prototype we created [1, 2, 9]. Luna was used in conjunction with Lynnette, an ITS that helps middle school students (grades 6–8) learn to solve linear equations in mathematics [5, 8]. Luna presents teachers with data about their students' performance in Lynnette, at the class and individual level. The analytics that Luna presents include information on students' skill mastery, misconceptions, and progress and time in the ITS.

Experimental Design. Five middle school teachers from two suburban U.S. schools took part in the study. The experiment had two conditions, control (9 classes) and experimental (8 classes). In this paper, we present data from the experimental classes only. First, students worked for 60 min in Lynnette. This work generated the data to be displayed on the Luna dashboard. Next, teachers were asked to use Luna and to think out loud as they prepared for a class session. These preparatory sessions lasted 20 min and were video-recorded. Subsequently, teachers conducted class sessions based on their lessons plans. During the class sessions (40 min each), 2–4 coders (undergraduate students and staff from our institution) took observational notes using a tool with predefined categories of observations. They also took free-form notes.

2.2 How Does the Dashboard Affect Teacher Practices in the Classroom?

We investigated how the dashboard affected teachers and their practices in the classroom, specifically: what teachers learned from the dashboard, their lesson plans, and their classroom sessions.

Teacher's Updated Knowledge. We analyzed the video recordings of the teacher preparation sessions to study how Luna affects teacher knowledge. From these video recordings, we distilled and paraphrased the statements teachers made while studying information presented by Luna. We distinguished four categories of statements, characterized by (a) whether the statements conveyed knowledge the teacher had *before* inspecting Luna or knowledge they became aware of *while* inspecting Luna, and (b) whether these statements referred to the class overall or to individual students. From the analyses of the teacher's updated knowledge, we found that Luna's information affected the teachers' knowledge. To varying degrees, this information (1) confirmed

what the teacher already knew, (2) surprised or rejected what the teacher knew, (3) added to what the teacher knew, about the class overall and about individual students.

Lesson Plan. To explore how the knowledge teachers gained from the dashboard may have influenced their lesson plans, we analyzed the lesson plans that teachers created as they prepared with Luna. We distilled and paraphrased the main ideas teachers were focusing on or wrote down during the preparation sessions, based on the video recordings of these sessions. The lesson plans specified the topics along with the exercises (if any) that teachers were going to cover in the class session, as well as their plans to interact with individual students, when applicable. We investigated how the information gleaned from Luna affected the teacher's lesson plan, by matching each of the statements in the lesson plan with information (in the form of statements) that teachers learned from Luna. This matching procedure was applied only to statements in which teachers explicitly said they were going to cover a topic or problem in the class session because of some information from Luna. We found that many of the statements and knowledge teachers gain from Luna is accounted for in various ways in their lesson plans, in particular knowledge about where students are struggling.

Class Session. We tracked whether teachers covered in class what they had planned in their lesson plans, using the notes taken during the class sessions by the coders. Part of the knowledge and statements teachers gain from Luna that makes it to their lesson plans also gets accounted for and reaches students in the class session.

3 Discussion

We examine and trace the influence of a dashboard for an ITS on teachers and their practices in the classroom. Our study is, to the best of our knowledge, the first to investigate effects of a dashboard in this manner.

Our findings show that Luna affects teachers' knowledge both at the class and individual level. In turn, the teacher's updated knowledge prompts them to adapt or change their lesson plan and what they decide to cover in class. Furthermore, teachers implement in the class session planned statements they learned from Luna. This is important, as ultimately, what teachers cover during the class session is what students get exposed to and what affects their learning. Overall, Luna provided useful information to teachers on how their students were learning with the ITS, affected their decision-making and planning for the class session, both with respect to the class as a whole and to individual students. Luna also influenced what happened during the class sessions.

Generally, we can conclude that the information that Luna provides (namely skill mastery information, occurrence of misconceptions and students time and progress in Lynnette), at the class and individual level, is helpful to teachers as they prepare for a class session and guides the lesson plans they create and the way they conduct the class sessions. More generally, the study provides strong evidence that a dashboard with information generated by an ITS can be a useful tool for teachers.

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