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Designing a Teacher Inquiry System with Teaching and Learning Analytics Using Fine-Grained Data

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Abstract: Fine-grained data collected in e-book systems allow educators to analyze them for the purpose of teachers' instructional inquiry. In response to studies that fail to take leverage insights from learning analytics to improve the teaching process, we theoretically proposed a system in which teachers metacognitively identify and analyze their educational issues and reflect to improve their teaching. Especially in this paper, we describe the theoretical background of the system and its function.

Keywords: e-book, teaching and learning analytics, teacher inquiry

1. Introduction

Fine-grained data such as clickstream logs from e-books can provide valuable insights into learners' behaviors through learning analytics (e.g., Yamada et al, 2024b). Al Saadi et al. (2017) indicate that e-books offer educational benefits by enabling learners to easily search content, thereby supporting both teaching and learning. In several learning analytics (LA) studies, researchers collected logs via e-book such as page transition or annotation and used these data to analyze instructional and provide feedback for teachers so that teachers can improve their instructional design (Suehiro et al., 2017; Shimada et al., 2018)

To design a feedback system using Learning Analytics (LA) for teachers, the concept of Teacher Inquiry (TI) can be valuable. TI supports teachers in identifying educational issues, defining specific questions regarding their educational design and delivery, and collecting evidence to answer those questions (Sergis et al., 2017). It also offers a useful framework for guiding teachers in interpreting LA insights to improve their instructional practice. However, Marsh and Farrell (2015) argued that although educators have access to extensive data, they often struggle to use it effectively to improve instruction, and therefore emphasized the need for theoretically grounded research to better understand the dynamic between educational interventions and evidence-based actions. Taken together, these perspectives suggest that TI-based LA systems have strong potential to enhance instructional design through effective data use.

The aim of this overall study is to design, develop, and evaluate a system based on a TI that enables teachers to interpret and analyze e-book logs and effectively link the insights from the analysis in TI. In this paper, we propose the design of the system.

2. System Design

2.1 Theoretical Background

One of the important factors in raising teachers' awareness of instructional design improvement is to track learner's metacognition. Jiang et al. (2016) claim that metacognition, generally defined as how individuals monitor and control their cognitive process, is important for teachers' instructional effectiveness. Yamada et al. (2024a) and Chen et al (2020), in their empirical study using e-book logs for LA, indicated that learning analytics dashboards (LADs), which provide visualized feedback of analysis data results based on the measurement, collection, and analysis of learning data and its contexts that take place within LA, are significantly related to metacognition, and self-regulated learning (Yamada et al, 2016).

However, in these systems, the final stage of instructional improvement, which involves applying insights from LA, is left to the individual agency of teachers, suggesting that there is room for further improvement. Sergis et al. (2017) pointed that LA has not yet fully accounted for the aspect of context (namely, educational design and delivery) which significantly affects learners' performance and progress. They proposed another analytics concept, teaching and learning analytics (TLA), which mainly focuses on capturing and analyzing the teacher actions during the educational design and delivery process to connect insights from LA to support teachers' instructional reflections and improvements based on evidence. In this paper, we aim to design TLA based on TI to promote continuous TI actions.

2.2. System Design

The structure of our system is based on six steps of the TI cycle framework. Table 1 summarizes how TLA contributes to each step of the TI cycle, as presented by Sergis et al. (2017), shows the correspondence between the functions and the framework in the system developed in this study. During the TA phase (step1, 2, and 3), teachers develop specific questions to investigate instructional issues they focus on and how they conduct their teaching activities based on these questions. These are recorded in the system, thereby metacognitively capturing their own challenges and actions. In the LA phase (step 4 and 5), the system provides visualized feedback to teachers through LAD, utilizing logs collected from the use of e-book system called B-QUBE utilized in our university. In the final phase of TLA, teachers reflect on their investigations based on their TA records and insights from LA.

Table 1*. Contributions of TLA and correspondence of our system functions in TI cycle*

Teacher Inquiry Cycle Steps	How TLA can Contribute	Functions in Our System
1. Problem Identification	Teaching Analytics can be used to capture and analyze the educational design and facilitate the teacher to: - pinpoint the specific elements of their educational design that relate to the problem they have identified and - elaborate on their inquiry question by defining explicitly the educational design elements they will monitor and investigate in their inquiry	The system allows teachers to clarify and record target issues for educational improvement, and to attach supporting materials such as past reflections or B-QUBE visualizations.
2. Develop Inquiry Questions		The system provides a function for teachers to record detailed analyses of identified problems, including the target situation and evaluation standards, to support the development of inquiry questions.
3. Educational Design		The system allows teachers to document instructional strategies by describing how they will act in class to achieve the goals set by their inquiry questions.
4. Deliver Educational Design and collect data	Learning Analytics can be used to collect the learner / teacher educational data that have been defined to answer their inquiry question.	The system automatically collects classroom material usage data from B-QUBE for LAD visualization, including page views, comprehension responses, notes, and highlighted text.
5. Analyze data	Learning Analytics can be used to analyze and report on the collected data and facilitate sense- making.	The system enables teachers to analyze LAD visualizations and obtain insights for answering their own inquiry questions, by recording key findings with screenshots of relevant graphs. It also allows flexible timestamp adjustment to examine data from specific moments.
6. Reflect on data	The combined use of TLA can be used to answer the inquiry questions and support reflection on educational design and delivery.	The system allows teachers to record their responses to the inquiry question based on prior insights, along with reflections on their instructional practices if needed.

Currently, we are developing a Learning Analytics Dashboard (LAD) that visualizes log data on educational material usage obtained from B-QUBE, mainly used in Step 5 of Table

1. As shown in Figure 1, the left panel shows how learners' current pages compare to the teacher's (categorized as same, ahead, or behind), the middle displays a heatmap of page transitions over time, and the right presents a line graph showing how the number of learners in each category (i.e., same, ahead, or behind) changes over time.

3. Conclusion

In this paper, we discussed the theoretically grounded design of a system intended to help teachers metacognitively identify their educational issues and use e-book logs as a medium for communicating insights to improve teacher inquiry (TI). As future work, we will continue developing the system, implement it in high schools where B-QUBE is used in daily classes, refine its UI and UX based on feedback from teachers, and select an appropriate evaluation method, considering metacognition and self-regulated learning, which can be challenge to improve TI (e.g., Prasse et al, 2024).

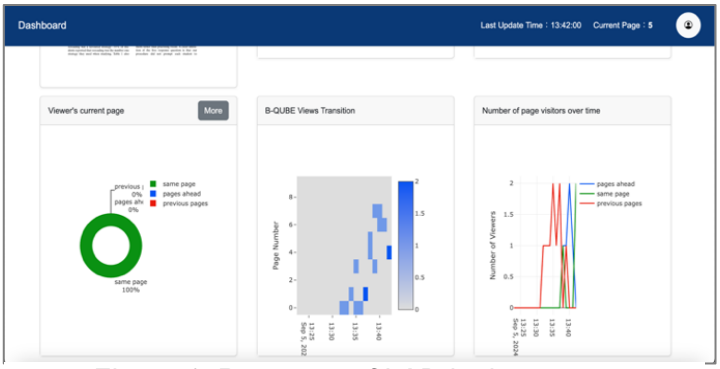

Figure 1. Prototype of LAD in the system

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