

Lumilo 2: A Scalable Mixed Reality System for Real-Time Teacher Analytics and Intervention

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Abstract. This interactive event presents Lumilo 2, a scalable mixed reality (MR) orchestration tool designed to support real-time teacher intervention during student learning with intelligent tutoring systems (ITSs). Building on previous work that demonstrated significant learning gains with MR teacher orchestration tools, Lumilo 2 reimagines this technology for modern and lightweight MR devices (Xreal Air 2 Ultra). Beyond real-time awareness, Lumilo 2 scales across ITS platforms and classrooms, advancing the goal of making data-driven teacher support broadly accessible in real-world settings.

Keywords: Mixed Reality · Real-Time Teacher Support · Classroom Orchestration · Intelligent Tutoring Systems (ITS).

1 Introduction

Well-designed technological tools promise to support teachers in running personalized K-12 classrooms, including classroom “orchestration tools” that show teachers analytics from student learning with software. In past research [1], we created and evaluated mixed reality (MR) smart glasses that show teachers real-time analytics of student learning software, working in close collaboration with teachers. A classroom study [1] found that when the teacher uses this tool, students learn three times as much as without the tool. Past work uncovered the need to expand the tool so it provides not only awareness support (informing the teacher about students’ progress and struggles), but also decision support (making suggestions for whom to help and how), with potentially even greater impact. In this work (<https://youtu.be/oJa50SrW9zw>), we tackle this challenge and broaden its applicability by deploying affordable MR headsets that integrate with multiple ITS platforms in blended middle-school mathematics classrooms.



Fig. 1. Lumilo 2 Overview. A demo video is available here.

2 Lumilo 2 System

This section presents the architecture and implementation of *Lumilo 2*. We first introduce the MR hardware that hosts the application, then describe the ITS it currently supports, and finally detail the system components that transform raw log streams into *in situ* visualized analytics for teachers.

Hardware Platform: Xreal Air 2 Ultra + Beam Pro. Lumilo 2 runs on the Xreal MR glasses (Air 2 Ultra) connected to an Android phone (Xreal Beam Pro). This binocular MR headset features a lightweight industrial design (120g) and achieves six degrees of freedom (6 DoF) inside-out tracking via dual grayscale cameras, with processing and rendering handled by the tethered smartphone. The platform offers two complementary input modalities: *hand tracking* for quick, natural gestures, and a *phone-based controller* for tasks requiring precise pointing or text input. These advantages, along with a 52-diagonal field of view, Xreal glasses enable teachers to maintain awareness of the physical classroom while interacting with virtual overlays.

Supported Intelligent Tutoring Systems. MR glasses are most effective when paired with up-to-the-minute analytics on student progress, struggle, and learning needs for visualization. Lumilo 2 interfaces with two ITS that differ markedly in curricular scope and internal data formats: *Tutorshop* offers guided practice in algebraic equation solving at eight progressively challenging levels (Figure 1). Fine-grained logs capture each step in a student’s solution strategy, yielding rich signals of progress and struggle. Carnegie Learning’s *MATHia* serves approximately 600k students in grades 6–12 across more than 2,000 schools. Each grade-level course comprises approximately 100 topical “workspaces,” within which students must show their work by completing multi-step problems. Compared with *Tutorshop*, *MATHia* produces larger and more heterogeneous transaction streams.

Building on the hardware and data sources, we next explain how Lumilo 2 converts these heterogeneous logs into coherent classroom visualizations.

Bridge Middleware. At the core of the system is *the Bridge*—a tutor-agnostic middleware layer that decouples Lumilo 2 from any single ITS. The Bridge ingests raw class and transaction logs from each ITS’s learning management interface, maps them to a unified event schema, and stores the result in a dedicated time series database. Detector algorithms (e.g. idle, struggle, system misuse,

working well) and a gradient-boosted recommender are executed entirely within this layer; their outputs are forwarded to the headset over a websocket protocol.

The preceding infrastructure enables four classroom-facing features: **Real-Time Awareness**. Compact MR overlays above each student encode the current detector state in real time, allowing instructors to identify struggling learners without approaching their desks. **Spatial persistence**. At classroom setup time, the instructor places a single room-level spatial anchor that defines a global coordinate frame. All student indicators are registered relative to this anchor, so returning to the classroom on subsequent days automatically restores the virtual layout. **Interaction Methods Settings**. Teachers can switch between hand gestures for quick inspection and the phone controller for scrolling through historical detail or entering text. **Decision Support (Prototype)**. Historical detector sequences feed a recommender that prioritizes intervention targets and suggests pedagogically appropriate actions. Future work will combine these data-driven predictions with teacher-authored heuristics to respect individual instructional styles.

3 Originality and Strengths

Lumilo 2 builds upon prior successful research [1] in MR classroom orchestration but introduces three innovations: **(1) Commodity-grade MR deployment**: We demonstrate this classroom orchestration tool that runs on sub-200g, <\$500 consumer glasses (Xreal Air 2 Ultra). By reducing cost and weight, Lumilo 2 enables large multi-school studies and paves the way for practical district-wide deployment. **(2) Scalability and generalization**: Lumilo 2 is designed to work across two ITS platforms, Tutorshop (a research-focused system by CMU) and MATHia (a scalable system by Carnegie Learning), thus supports multiple teachers and classrooms. A dedicated security layer through bridge middleware ensures the safe storage and protection of student and class data, supporting deployment beyond single-school settings. **(3) Decision support integration**: existing real-time teacher support tools focus primarily on enhancing teacher awareness and also supporting intelligent intervention recommendations [2]. Our system goes further, generating data-driven recommendations on whom to help and how. An upcoming classroom study will test how this added decision support shapes teacher actions and student learning.

References

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