K-12 Embodied and Mediated Learning: the SMALLab Mixed-Reality Learning Environment

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1. ABSTRACT
In recent years, much work in K-12 educational technology has shifted away from addressing the problem of mere accessibility and toward a greater emphasis on the effective design of learning environments that make innovative use of emerging digital technologies. Contemporary research in the Learning Sciences reveals the importance of well-designed, student-centered learning environments that are situated in an appropriate context; engage today’s participatory culture; speak to 21st century literacies; and enable collaborative, distributed and embodied cognition. Recent research in the Human Computer Interaction (HCI) community has yielded tools and paradigms to enable collaboration, embodied interaction, and multimodal interaction within computational frameworks.

Looking across these disciplines we have identified four key areas of convergent research that, when applied to the design of interactive learning environments, can yield truly transformative results: embodiment, computational mediation, collaboration, and multimodality. By embodiment we mean interactions that engage students both in mind and in body, encouraging them to physically explore concepts and systems by moving within and acting upon an environment. By computational mediation we mean that students interact with computational technology that monitors their actions and provides real-time feedback with respect to those actions. By collaboration we mean that large groups of students and teachers can engage one another in direct face-to-face interaction within and around the learning environment. By multimodality we mean interactions that encompass students’ full sensory and expressive capabilities including visual, sonic, and kinesthetic.

Despite this promise, three significant challenges can prevent such work from achieving a broad impact in real world contexts. First, due to their cost and complexity, many leading edge interaction environments remain sequestered in specialized facilities, inaccessible to the students and educators who might benefit most. Conversely, many web-based and desktop applications that can readily scale to large user groups, fail to engage the capabilities of learners due to the limiting nature of the mouse/keyboard interface. Finally, all too often, educators and media designers fail to deeply collaborate. As a consequence, researchers are left to make design decisions that are not rooted in an appropriate theoretical base and educators are offered unwieldy tools that do not address the needs of their students.

Our work represents a significant advance in the domain of technology-enabled K-12 learning through the purposeful integration of the trans-disciplinary research described above that has two facets. Specifically:

- We have developed the Situated Multimedia Arts Learning Lab [SMALLab], a mixed-reality learning environment that allows learners to engage through full body 3D movements and gestures within a collaborative, computationally mediated space. SMALLab enables emerging interactive learning approaches to reach a broad population of students and educators in a low cost package.
- We are guided by a grounded design approach to the collaborative design of learning scenarios that features ongoing, deep collaboration through a professional learning community comprised of a cohort of K-12 teachers, students, media researchers, and artists.

![Figure 1. SMALLab mixed-reality learning environment](image)
themselves in order to address the specific needs of their students and curricula.

**SMALLab** supports situated and embodied learning by empowering the physical body to function as an expressive interface (Birchfield et al., 2006). Within **SMALLab**, students use a set of “glowballs” and peripherals to interact in real time with each other and with dynamic visual, textual, physical and sonic media through full body 3D movements and gestures. For example, working in the *Spring Sling* scenario, students are immersed in a complex physics simulation that involves multiple sensory inputs to engage student attention. They can *hear* the sound of a spring picking up speed, *see* projected bodies moving across the floor, *feel* a physical ball in their own hands and integrate how the projected ball moves in accordance with their own body movements to construct a robust conceptual model of the entire system.

![Figure 2. Whole class learning in a mediated titration lab](image)

Physically, **SMALLab**, is a 15’W x 15’W x 12’H freestanding, interactive space. A cube-shaped trussing structure frames its open architecture and supports the following sensing and feedback equipment: a six-element camera array for object tracking, a top-mounted video projector providing real time visual feedback, four audio speakers for surround sound feedback, and an array of tracked physical objects (*glowballs*). A networked computing cluster with custom software drives the interactive system.

Over the past two years, our team has deployed **SMALLab** in a series of pilot programs that have reached over 25,000 learners through regional school and museum programs (Birchfield et al., 2008, Cuthbertson et al., 2007, Hatton et al., 2008). In Summer 2007 we began a long-term partnership with a large urban high school in the greater Phoenix, Arizona metropolitan area. We have permanently installed **SMALLab** in a classroom and are working closely with teachers and students across the campus to design and deploy new learning scenarios. We have conducted a series of pilot studies to determine the efficacy of **SMALLab** as a teaching and learning environment. We apply a mixed-methods approach to evaluation that includes pre- and post-treatment concept tests, observation instruments, spatial reasoning tests, interviews, standardized tests, and in-system computational data generated by **SMALLab**. We have documented statistically significant gains by participating students across multiple grades and subject areas.

2. **DEMO**

During this highly interactive demo session, we will share a series of recent **SMALLab** learning scenarios that illustrate our approach. Figures 2 and 3 show two such scenarios. Here we see high school students and teachers interacting to learn Geology and Chemistry topics. We will also present learning scenarios for Physics, English Language Arts, and English Language Learning. Workshop attendees will be invited to directly participate in the scenarios for a hands-on, interactive session that will allow them to experience the learning environment from a student perspective. In addition we will summarize the results of our evaluation of student learning in **SMALLab** for each of the presented scenarios.

![Figure 3. Students collaborate in real time to construct a geological structure](image)

For more information and media documentation about this project please visit [http://ame2.asu.edu/projects/emlearning](http://ame2.asu.edu/projects/emlearning).

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