Embodied and Mediated Learning in SMALLab: a student-centered mixed-reality 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 three key areas of convergent research that, when applied to the design of interactive learning environments, can yield truly transformative results: *embodiment*, *computational mediation*, and *multimodality*. By *embodiment* we mean interactions that engage students both in mind and 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 *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 emerging interactive 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 (*http://ame2.asu.edu/projects/emlearning*) represents a significant advance in the domain of technology-enabled K-12 learning through the purposeful integration of the trans-disciplinary research described above. 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.

Evaluation and Results: As evidence of the scalability of our efforts, over the past two years we have reached over 25,000 students, community members and teachers. A *SMALLab* system is currently installed – on a permanent basis - in a large urban public high school. In collaboration with a cohort of high school teachers we are designing, implementing, and assessing innovative programs in earth science, chemistry, physics, and language arts that reach across the school community.

We apply a mixed method approach to evaluation to assess the efficacy of *SMALLab* for learning. Through empirical research in the schools, we have documented statistically significant learning gains by students by using invariant pre- and post-tests of standards-based content knowledge. We have observed improved performance by teachers in SMALLab through the use of an observational rubric that assesses the nature of student-centered learning in the classroom. In addition, our research team has begun to formalize of a comprehensive design rubric with metrics that address the technological, pedagogical, and scalability needs of mixed-reality learning scenarios.

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