SMALLab: A Mixed-Reality Environment for Embodied and Mediated Learning

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ABSTRACT

In this video presentation, we introduce the Situated Multimedia Arts Learning Lab [*SMALLab*], a mixed-reality learning environment that supports interactive engagement through full body 3D movements and gestures within a collaborative, computationally mediated space. The video begins by describing the holistic approach to embodied and mediated learning developed by our transdisciplinary research team, grounded in understandings derived from research in the learning sciences, digital media and human computer interaction. We then outline the three core tenets of effective learning exemplified by our research – embodiment, multimodality and collaboration. The video next demonstrates the design and functionality of the physical and digital components of *SMALLab*. We conclude by illustrating our partner collaborations with K12 teachers and students with four scenarios depicting Geography, Physics, Language Arts and Chemistry learning modules.

Categories and Subject Descriptors

K.3.1 [**Computers and Education**]: Computer Uses in Education – *collaborative learning, computer-assisted instruction*

General Terms

Algorithms, Documentation, Performance, Design, Experimentation.

Keywords

K-12 Education, Situated Multimedia, Learning, Experiential Media, Student Centered Learning Environments, Interactivity

1. INTRODUCTION

In this video presentation, we introduce the Situated Multimedia Arts Learning Lab (*SMALLab*), a mixed-reality collaborative learning environment that supports interactive engagement through embodied gestures. Our student-centered environment creates situated learning opportunities that are participatory, highly collaborative and authentically embodied. Informed by research initiatives in the Learning Sciences, Digital Media and Human Computer Interaction, we have identified three primary elements necessary for effective learning – embodiment [3], multimodality [4] and collaboration [7].

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The design and functionality of *SMALLab* aims to directly support these three key areas by encouraging physical exploration and movement, providing visual, sonic and kinesthetic input and feedback mechanisms and implementing scenarios that require meaningful collaborative action and participation.

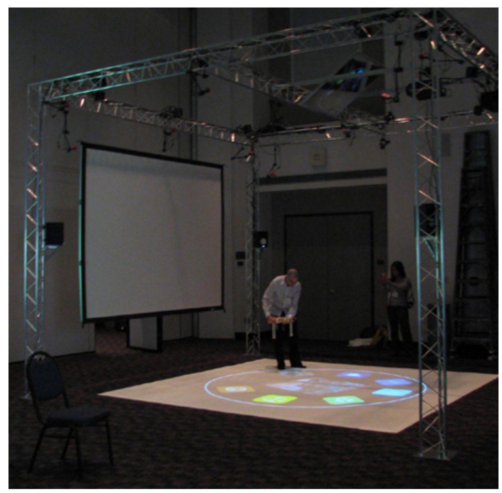

Figure 1. ***SMALLab*** **Mixed Reality Learning Environment**

Our video presentation demonstrates four learning scenarios that have been developed by a highly collaborative professional learning community, comprised of K-12 teachers, students, artists and digital media researchers and educators. Through iterative, ongoing interactions, our learning community has designed, implemented and evaluated multiple learning scenarios in the areas of Physical and Life Sciences, Language Arts and English Language Learning. In the remainder of the paper, we describe the physical and digital components of *SMALLab* (Section 2), the motivation, design and implementation of four learning scenarios (Section 3) and outline current and future research directions with our collaborating partners (Section 4).

2. SMALLAB ENVIRONMENT

The *SMALLab* physical manifestation is a 15x15x12 freestanding environment, framed by an open rectangular trussing structure designed to support multiple types of sensing and feedback equipment. Figure 1 depicts a typical *SMALLab* configuration including an array of six to twelve cameras for detecting the movement of trackable hand-held objects (called *glowballs*) in the space. A top-mounted video projector floods the interaction floor with real time visual feedback, while four truss-mounted audio speakers provide surround-sound feedback. The sensing and feedback data is handled by a networked computing cluster running custom-designed software. High-level authoring tools allow students, teachers and researchers to develop, modify, adapt and extend learning scenarios, while an online community portal is being developed to facilitate the reflective documentation and sharing of learning experiences.

SMALLab is a modular, reconfigurable environment that can be custom-fit to accommodate the physical, financial and logical constraints of contemporary classrooms, learning centers and education labs. The *SMALLab* environment has been deployed in multiple settings over the past two years and has reached over 25,000 students and learners through numerous school, workshop and museum programs [1,5].

3. SMALLAB SCENARIOS

The video presentation depicts four learning scenarios that have been designed, developed and evaluated by our professional learning community to enhance Earth Science, Physics, Language Arts and Chemistry education.

3.1 Contour Creation

The goal of this scenario is to help Earth Science students interpret and understand 2-dimensional representations of real 3-dimensional physical structures. The scenario is designed to provide collaborating students with real-time visual and audio feedback as they work in 3-dimensional space to construct 3-D structures corresponding to 2-dimensional representations. Figure 2 depicts students interacting with the system using a trackable object for creating contour shapes and a game controller for manipulating levels and undoing/redoing actions.

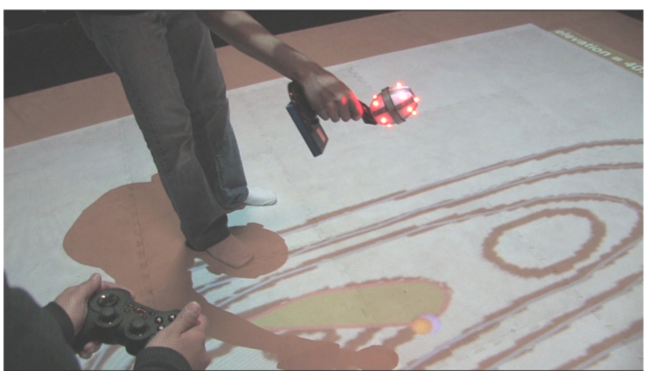

Figure 2. Contour Creation Scenario interaction objects

3.2 Constant Velocity

The purpose of this scenario is to challenge common misconceptions regarding physics identified in prior research as remaining problematic to students despite classroom instruction [5]. This game-based scenario is designed to allow students move rapidly between action in the physical world and abstract representations in the digital realm in the form of diagrams, graphs, and equations, as shown in Figure 3. Students work and compete in teams using the glowballs to create, perform and analyze movement sequences with constant velocity.

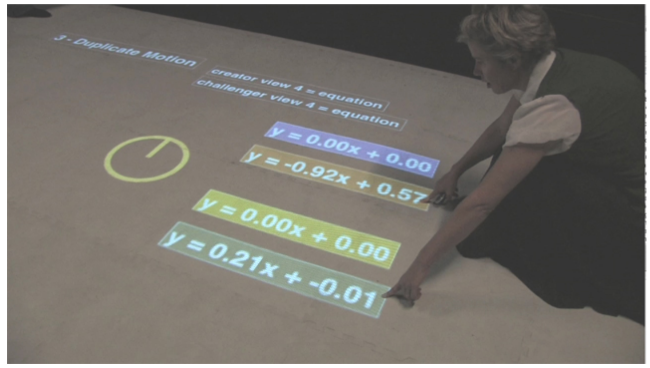

Figure 3. Constant Velocity Scenario abstract representations

3.3 Embodied Poetry

The motivation for this scenario is to encourage English Language Learners to thoughtfully consider the meaning of challenging vocabulary words, concepts and metaphors. In this scenario, students design, create and experience each other's Action Poems, by enacting movements that illustrate the meaning and relationship between complex words and phrases. Students use the glowballs to record movement sequences and manipulate the custom-designed authoring tools to create word compositions. Figure 4 shows students examining an Action Poem in the *SMALLab* interaction space.

Figure 4. Embodied Poetry Scenario exploration space.

3.4 Chemistry Titration

The goal of this scenario is to help students learn about acids, bases, titration and neutralization – concepts and processes that students often have difficulty understanding at the molecular level. The scenario is based on the notion of a traditional chemistry titration lab, where students iteratively add a known solution of acid or base to a known reactant of *unknown* molarity until the endpoint of reaction occurs. Chemical reactions that unfold in the traditional lab are complimented by *SMALLab's* multimedia elements in order to promote active dialog about titration at both the molecular and system level. Students interact by using glowballs to select, release and energize acid, base and indicator components in the central 'water' interaction space, as displayed in Figure 5.

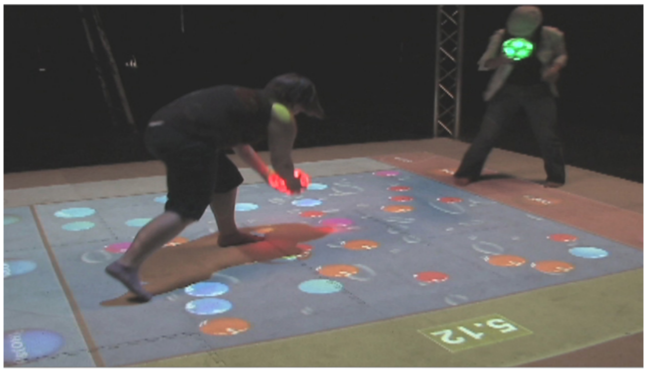

Figure 5. Students interacting with the Titration Scenario

4. CURRENT AND FUTURE DIRECTIONS

A *SMALLab* system is currently permanently installed in a large urban high school, while two other system implementations will be installed in additional schools in Fall of 2009. A mobile version of the system has also been installed on a temporary basis at media conferences, large science museums and contemporary art galleries. Through these installations, we have reached over 25,000 students, community members and teachers in the last two years, gaining valuable insights into the transformative impact of embodied, multimodal, collaborative learning. We currently employ a mixed method approach to evaluation for assessing the efficacy of the *SMALLab* environment for learning. We have documented statistically significant learning gains by students using invariant pre- and post-tests of standards-based content knowledge [2] and have recorded observational evidence of substantial performance improvement by teachers using *SMALLab* [8].

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