SMALLab for Special Needs: Using a Mixed-Reality Platform to Explore Learning for Children with Autism

Lisa Tolentino
Arts, Media and Engineering Dept.
Arizona State University
Tempe, AZ
(+01) 661.301.9856
lisa.tolentino@asu.edu

David Birchfield
Arts, Media and Engineering Dept.
Arizona State University
Tempe, AZ
(+01) 480.965.3155
dbirchfield@asu.edu

Aisling Kelliher
Arts, Media and Engineering Dept.
Arizona State University
Tempe, AZ
(+01) 480.727-0997
aisling.kelliher@asu.edu

ABSTRACT
Special education teachers are eager but struggling to move their students forward in the digital age. Guidelines for Universal Design for Learning (UDL) indicate that multiple means of representation, expression, and engagement are essential for creating a more widely accessible curriculum. Recent emerging technologies and human-computer interaction techniques offer opportunities to transform learning in these ways. Over the past 18 months, the K-12 Embodied and Mediated Learning Group in the Arts, Media and Engineering Program (AME) at Arizona State University (ASU) has partnered with a large urban high school in our region. We have undertaken a series of pilot studies using a new mixed-reality learning environment, SMALLab, working with teachers and students to collaboratively design learning scenarios that implement UDL approaches to learning for a diverse student population across multiple subject areas. Building from this prior work, we are involved in the early stages of a partnership with a group of teachers to extend this work for people on the autistic spectrum (PAS). We are designing a set of interactive scenarios and collecting data to determine how autistic students can engage in SMALLab. Our goals are to better understand how mediated environments can benefit students and teachers in special education, and to define a framework for developing mixed-reality learning scenarios that implement UDL.

Categories and Subject Descriptors
D.2.6 [**Software Engineering**]: Programming Environments – *interactive environments*. K.4.2 [**Computing Milieux**]: Social Issues – *Handicapped persons/special needs*.

General Terms
Design, Experimentation, Human Factors.

Keywords
Special Education, Mixed-Reality, Autism, High School.

1. INTRODUCTION
Special education has had limited opportunities involving the use of creative digital technologies and new media in the classroom. As a result, students in special needs classrooms are falling behind their 'non-disabled' peers in their exposure to digital tools and learning. While special education still aims to close the gap between their students' abilities and the basic standards of their non-disabled peers, general education is already moving forward, extending its standards to include digital learning and media technology in the classroom—part of a greater 21st century learning initiative emerging throughout the United States. As general education conceives of what it means to create classroom opportunities for 21st century learning, we wonder, what is 21st century learning for children with special needs?

The K-12 Education Group in the Arts, Media and Engineering Program (AME) at Arizona State University recognizes the need to create opportunities for all students to engage in classroom opportunities promoting digital learning. We have partnered with Coronado High School teachers in science, physics, and language arts to develop mediated classroom experiences using a mixed-reality learning environment. In the Fall of 2008, we began work to establish a pedagogical foundation that lets us extend SMALLab to the autism classroom. Our efforts are guided by principles established through the Center for Applied Special Technology (CAST), an active dialogue with the Special Education department at ASU, and a strong relationship and commitment to the children and their teachers.

2. CONTEMPORARY APPROACHES TO MEDIATED LEARNING
To motivate our work, we are looking closely at projects supporting CAST's UDL guidelines, methodology and findings from University of Portsmouth's *MEDIATE* project, and our Spring 2008 teaching experiment involving SMALLab and the use of best practices for science education in the high school chemistry classroom. We also describe a contrasting approach to design for learning - one that constructs a more self-contained environment for behavioral management rather than an inclusive environment with multiple pathways for expression and learning.

2.1 CAST and Universal Design for Learning
Growing out of the architectural movement for Universal Design and the inclusive redesign of school curriculums as outlined by Individuals with Disabilities Education Act (IDEA) and No Child Left Behind (NCLB) legislation, CAST created the guidelines of *Universal Design for Learning (UDL)* to offer a framework for developing a more widely accessible curriculum that is consistent with links to digital technology. UDL calls for multiple means of representation for knowledge networks, multiple means of action and expression for strategic networks, and multiple means of engagement for affective networks [5]. Currently, the primary

Workshop on Media Arts, Sciences, and Technology '08, January 29-30, 2008, Santa Barbara, CA, USA.

focus for digital technology in UDL involves the re-representation of printed instructional materials (such as textbooks) through the creation of more flexible formats. CAST's support for NIMAS (National Instructional Materials Accessibility Standard)—a standard meant to guide the production, markup, and electronic distribution of flexible digital instructional materials—supports information accessibility through *augmentative and alternative communication* devices such as screen readers, Braille documents, or a Picture Exchange Communication System (PECS).

CAST also supports the research and development of systems that adapt to students' learning styles. One example is CLIPPS (Custom Learning Interface Production from Pedagogic Semantics), an intelligent system built to recognize individual needs and customize the presentation of learning materials to meet those needs at the point of instruction. The target of the adaptation focuses on the presentation of learning materials, a focus which is aligned with legislation on educational standards for content learning and assessment. This still leaves room to broaden the scope of the use of digital systems for special needs, particularly in the ways of learning about learner expression and engagement.

2.2 The MEDIATE project for autism

The University of Portsmouth has approached the engagement and creative exploration of people in the autism spectrum (PAS) through its MEDIATE project. *MEDIATE* (*Multisensory Environment Design for an Interface between Autistic and Typical Expressiveness*) is a fully immersive environment designed to foster a sense of agency and a capacity for creative expression in people with autism. [4] Autism is a variable neuron-developmental disorder in which PAS are overwhelmed by the excessive stimuli, the noises and colors that characterize interaction in the physical world. Perhaps as a result (although exact mechanisms and causes are unknown), PAS withdraw into their own world, posing difficulty in their everyday social interactions as well as their ability to express themselves creatively. *MEDIATE* was co-designed by PAS to as an immersive 3D environment where stimuli are focused and simplified, yet dynamic, engaging and capable of affording a wide range of creative expression. The *MEDIATE* infrastructure is a hexagonal room comprised of a pair of planar screens alternating with a pair of tactile interface walls.

MEDIATE is particularly impressive in its ability to replace the traditional classroom environment with one much more conducive to learning in the context of PAS. However, *MEDIATE* remains a specialized platform for rehabilitating PAS and has not been used in conjunction with the more complex learning goals that arise in process of everyday classroom instruction.

2.3 Virtual reality and autism

Studies regarding children with autism and virtual reality have shown that many of these children relate especially well to virtual reality. Northwestern's Center for Technology and Social Behavior [1] has completed extensive work with autistic children and virtual playmates. University of North Carolina's Division of TEACCH [2] director Gary Mesibov has also recognized virtual reality simulations as capable of helping autistic children learn and transfer new skills back to a real situation [7]. These efforts highlight ways in which PAS can learn life skills. Our approach is different in that we do not seek to "correct" a child's behavior, but instead, question our notion of universal curricular design by challenging assumptions we have made about how we provide multiple pathways for expression and learning. Activities focused on single-task learning or behavior management may be limiting our ability to see new types of learning. To ensure that children with special needs are not further surpassed by society as it moves forward with digital technology, it is essential for special needs students to participate in media culture and the development of new tools for their own use and expression. Their contributions to the design process will help us develop our knowledge and understanding of the strategies we need to build UDL principles into every learning scenario we design.

3. USING A MEDIATED ENVIRONMENT IN THE HIGH SCHOOL CLASSROOM

The Arts, Media and Engineering Program (AME) at ASU has partnered with Coronado High School in Scottsdale, Arizona, to develop mediated learning scenarios using a mixed-reality platform. Scenario development occurs through a Professional Learning Community (PLC) that meets weekly. The PLC is a team of high school teachers, educators, and researchers in music, art, design and technology that meet regularly to develop curriculums and strategies for teaching content and conceptual learning in AME's mediated environment for learning, also known as SMALLab.

3.1 What is SMALLab?

SMALLab (the Situated Multimedia Arts Learning Lab) is a mixed-reality environment that affords face-to-face interaction by co-located participants within a mediated space. This environment is developed by a team of researchers (including the authors) with backgrounds in education, psychology, design, interactive media, computer science, and the arts. SMALLab is an extensible platform for mixed-reality learning in a *semi-immersive* setting, meaning that the mediated space is physically open on all sides to the larger environment. This lets participants freely enter and exit the space without the need to wear a special display, sensing devices, or motion capture markers. Participants outside of the space can both see and hear dynamic media and can directly communicate with peers interacting inside the space.

3.2 SMALLab Chemistry at Coronado High School

During the spring semester of 2008, AME researchers and faculty met with Coronado High School science teachers to create a PLC to design, implement, and assess a SMALLab learning scenario for Coronado's chemistry classes. [6] Based on curriculum standards and student needs, the teachers decided to use SMALLab to help students conceptualize the chemistry models of titration and neutralization at the molecular level. For six weeks, the team's developers prototyped and improved upon the scenario's mechanics and audio-visual display. Meanwhile, the teachers and educators developed strategies for engaging students and facilitating methods of scientific inquiry in SMALLab.

The scenario used auditory cues and visual displays to represent chemical information in multiple ways. For example, acid and base molecules are represented using a two-color schema to delineate similarities and differences between molecular properties. Unique audio samples were triggered to indicate that specific chemical reactions had occurred. A textual display showed the current value of pH. These representations let students observe and express their understanding of a chemical system in multiple ways; they connected their descriptions of sound, color, and the movement of molecules to chemical concepts learned in their regular classroom. Their ability to select, add, and place a particle with a location and speed based on their movements gave them an opportunity to take the perspective of a particle and engage with molecules in a physically embodied way.

Figure 1. Coronado High School chemistry teacher uses SMALLab Chemistry Scenario during class.

We designed the chemistry scenario to motivate students to understand molecular chemistry at a deeper level. Through multimodal representations, we tried to engage students by giving them an immersive, media rich experience in chemistry. During our teaching experiment, we also tried to learn *how* students were learning: how they synthesized conceptual understanding with their SMALLab experience, how they moved in and around the space, how they responded to multiple modes of feedback, and how they demonstrated their knowledge.

A comparison of student pre-test and post-test results showed that students had significant gains in conceptual knowledge, reasoning, and spatial reasoning abilities. Field observations and video transcripts showed evidence of improved reasoning skills, student collaboration, and consistent use of the mediated environment to develop shared conceptual knowledge of chemical equilibrium and reactions. Gains in the Reform Teacher Observation Protocol assessment indicated that teachers demonstrated use of best teaching practices. Statistical gains were also complemented by evidence of high engagement and motivation in students, with one student remarking, “That’s the first time I *got* chemistry this entire year.”

From these observations, we want to evolve what we already know about “average student” learning in SMALLab by designing SMALLab scenarios for children with more challenging needs. How do they make choices and express themselves in a mixed-reality, multimodal environment?

4. METHODOLOGY

Our pilot study is currently in progress and is on schedule for development, data collection and preliminary analysis by January 2009. Our approach begins with observations in the general autism classroom, following Geertz’s method of “thick description” [3] as our observational framework. The primary author has been spending time with students and making observations in the autism classroom during one class period each week, about every week since September of 2008, interacting with students and shadowing teachers and teacher aides during learning and leisure activities. Because the level of needs and preferences are specific from child to child, we will use existing studies only as a baseline for understanding these children’s relationship to digital technology. More importantly, we are working closely with the teachers and building a trusting, respectful relationship with students to establish a scenario that would be most comfortable for all members of the classroom.

In November 2008, the teacher and the students visited the SMALLab environment to determine which students felt comfortable in the space. Discussions and brainstorming sessions have followed over the types of creative activities or mediated experiences the teacher wants to try with her classroom. From these discussions, we have been building pilot interactions for students to explore. These interactions allow students to make choices about musical and visual preferences. These choices are implemented as plug-ins, with music plug-ins written using JSyn (Java audio synthesis API created by SoftSynth) and visual plug-ins developed in Objective C language/Open GL using visualization software by Loren Olson (AME faculty).

We are now inviting students to explore the developed interaction scenarios, where we carefully observe and collect data about how the children approach and interact in each environment. Data collected from these studies will guide our direction for building a more formal scenario later in the Spring of 2009.

5. ACKNOWLEDGEMENTS

We express our deep gratitude to Special Education faculty Elizabeth Kozleski, Sarup Mathur, and Heather Griller Clark in ASU’s Department of Education; Coronado H.S. teacher Shannan McClure; and AME faculty Ellen Campana, for their ongoing guidance and support in building a foundation for this work.

6. REFERENCES

[1] Articulab. “Innovative Technologies for Autism,” http://articulab.northwestern.edu/projects/samautism/ [Accessed 14 Nov. 2008.]

[2] Division Teach. http://www.teacch.com/ [Accessed 14 Nov. 2008.]

[3] Geertz, Clifford. "Thick Description: Toward an Interpretative Theory of Culture." The Interpretation of Cultures. New York: Basic Books, 1973.

[4] Parés, N., A. Carreras, J. Durany, J. Ferrer, P. Freixa, D. Gómez, O. Kriglanski, R. Parés, J. Ribas, M. Soler, and À. Sanjurjo. (2004). “MEDIATE: An interactive multisensory environment for children with severe autism and no verbal communication. 3rd International Workshop on Virtual Rehabilitation.” (IWVR'04)

[5] Rose, D. H., A. Meyer, et al. (2005). The universally designed classroom: accessible curriculum and digital technologies, Cambridge, MA: Harvard Education Press.

[6] Tolentino, L., Birchfield, D., Megowan, C., Kelliher, A., Martinez, C., Johnson-Glenberg, M. (2008). “The SMALLab Science Classroom: Collaborative, Conceptual Learning in Mixed-Reality Environments for High School Science,” Journal of Science Education and Technology. (under review)

[7] Nelson, B. “Virtual reality helps autistic kids develop skills,” (21 April 2008) http://www.msnbc.msn.com/id/24100671/ [Accessed 14 Nov. 2008.]