

# A Morphing Robotic Environment Shaped by and Shaping Kindergarteners, Reaching for the Stars

**Anthony L. Threatt,  
Keith Evan Green**  
School of Architecture  
Clemson, SC 29632  
anthont,  
kegreen@clemson.edu

**Jessica Merino, Ian D.  
Walker, Megan R. Milam**  
Department of Electrical  
and Computer Engineering  
Clemson, SC 29632  
jmerino, iwalker,  
mrmilam@clemson.edu

**Michelle V. Buckley,  
M. S. Ellison**  
School of Material Science  
and Engineering  
Clemson, SC 29632  
mvbuckl,  
ellisom@clemson.edu

## ABSTRACT

Our world is digital, physical, social and technological. Informal learning environments that are likewise digital, physical, social and technological have the potential to afford children with creative, informal learning explorations. Following from Antle's concept of "embodied child-computer interaction" and Vygotsky's "cycle of creative imagination," we demonstrate an intelligent, robotic informal learning environment at room-scale targeted for K-3 visitors to a regional children's museum. Our reconfigurable environment is, in essence, co-adaptive, allowing the physical learning environment and young students to mutually change and develop through iterative interactions.

## Author Keywords

Computer Support Tools; Children; Creativity; Intelligent Environments, Architecture, Design; Human Factors, HRI

## ACM Classification Keywords

H.1.2 User/Machine Systems; I.2.9 Robotics, K.3.1 Computer Uses in Education

## General Terms

Design, Human Factors

## INTRODUCTION

How can Intelligent Environments help cultivate in children creative exploration and life-long learning? Our response, a robotic informal learning environment at room scale, is informed by Alissa N. Antle's concept of "embodied child-computer interaction" [1]. According to Antle, "meaning is created through restructuring the spatial configuration of elements in the environment" [1].

While there is ample literature regarding creativity, learning environments, and the growing influence of technology on

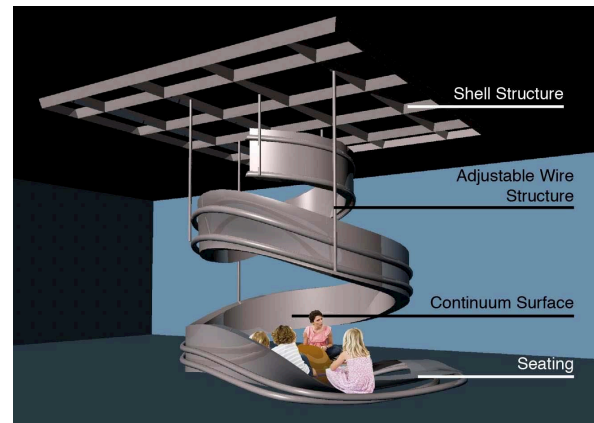


Figure 1. Our concept of a robotic learning environment

children, the literature on the important effects of the interactions of these domains has not yet emerged. Our research in child-computer interaction seeks to fill this gap by focusing on a reconfigurable, computationally-embedded physical environment fostering creative explorations and life-long learning in children K-3.

## THE CYCLE OF SEASONS AND THE CYCLE OF CREATIVE IMAGINATION

Have you ever carefully observed the tendencies of children playing on a playground? What draws them? What goals do they exhibit? Our research team conducted observational sessions at a local playground focused on the behaviors children exhibit towards static and dynamic playground equipment. We noted, in verification of Antle, that children tend to shape their environment: when given the opportunity, children manipulate dynamic playground equipment to create an environment that satisfies their needs and wants, even if this means reaching outside the boundaries that playground designers envisioned. Children shape their surroundings to give form to their thoughts and ideas, and to make visible and tangible these thoughts and ideas for inspection by themselves and others. This energetic manipulation of the environment lends children a sense of ownership and control of their inner thoughts and their external surroundings, each one made to reflect the other. These observations find theo-

retical validation in Antle as well as in the four-step “cycle of creative imagination” proposed by Vygotsky informing our research: exploration (a haptic, sensorial experience of the world), inspiration (an analysis of these impressions), production (a creative act informed by the analysis) and sharing (the presentation of an outcome) [5]. Vygotsky’s cycle has informed related HCI work in non-robotic, informal learning environments [2].

Certain concepts are too abstract to be brought to reality by young children, given the character and equipping of their environmental surroundings [4]. Our research team comprised of faculty and students in Robotics, Architecture, Education and Human Factors Psychology are exploring, through working prototypes and virtual simulations, a digital-physical, robotic learning environment at room-scale (figure 1) supporting child-centered creative play, and advancing cognitive skills and understanding. This physical-digital learning environment features a continuum robotic surface embedded with an RGB display that morphs in shape and texture to facilitate a child’s hands-on comprehension of such concepts. A video of our vision and our working prototypes is found at <http://youtu.be/FXawb88FUhg>.

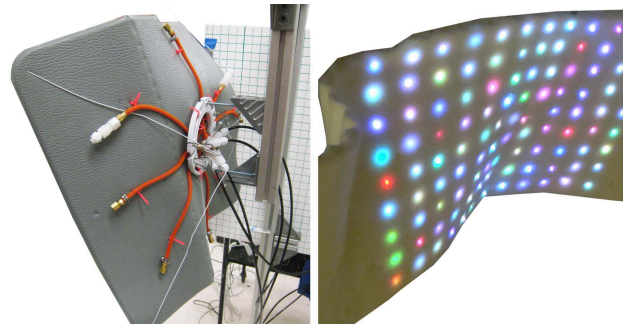


**Figure 2. Children and teacher using tangible interface; Interactive system display - in-concept.**

One abstract concept identified as an important case in Education is “seasonal change” [3] which we test with our working prototype. Children, engaging our informal learning environment, physically manipulate spherical objects representing the Earth, sun, and moon by translating the two spheres representing Earth and moon about two rods representing their orbits (figure 2). In doing this, children explore the orientation of these celestial bodies to “create,” for example, a summer day in Lima, Peru. Following changes made by the children to this tangible interface of spheres and rings of movement, the environment’s morphing surface and RGB display exhibit sensations of colors, temperature, wind and even humidity - the atmosphere - of that summer day in Lima, or a harsh winter in northern Norway, or an early autumn storm on the coastline of Cuba. Setting the spherical objects to specific positions along the “orbital” rods morphs the environment’s helical surface and alters the RGB display to create sensations of the seasonal conditions at points around our planet. This makes the abstract concept of seasonal change that much more tangible to young children.

Categorized as “continuum robots” for their infinite degrees of freedom, the “soft” pneumatic muscles employed here (figure 3) actuate the ribbon surface, helical in form to create

activity towards the ceiling (engaging individuals at a distance) as well as closer to the floor (engaging children interacting more directly with the tangible interface). The shapes the morphing surface assumes depend on the length, diameter, number and configuration of the muscles and the material selected to comprise the helical surface. Our lab continues to test different configurations of muscles and materials to optimize movements that reflect, in three-dimensions, the character of seasonal change.



**Figure 3. Our prototypes showing muscles and RGB display**

## CONCLUSION AND DEMONSTRATION

The reconfigurable nature of our informal learning environment makes it, in essence, co-adaptive, allowing environments and their inhabitants to change and develop through iterative interactions. “An environment . . . that supports multiple spatial configurations,” as Antle offers [1], promises to advance a child’s grasp of our universe through active, creative exploration.

Our demonstration includes a working prototype of one segment of the larger, helical morphing ribbon embedded with pneumatic muscles and the RGB display, as well as a video showing a virtual simulation and the full-scale physical working prototype.

## REFERENCES

1. A. N. Antle. Embodied child computer interaction: Why embodiment matters. *interactions*, XVI.2:27–30, March / April 2009.
2. F. Decortis and L. Lentini. A socio-cultural perspective of creativity for the design of educational environments. *eLearning Papers 1 N 13*, April 2009 [www.elearningpapers.eu](http://www.elearningpapers.eu).
3. T. Keating, M. Barnett, S. A. Barab, and K. E. Hay. The virtual solar system project: ... *Journal of Science Education and Technology*, 11(3):261–275, 2002.
4. P. Schwanenflugel. Why are abstract concepts hard to understand? In P. Schwanenflugel, editor, *The Psychology of Word Meanings*. LEA, Hillsdale, N.J., 1991.
5. L. S. Vygotsky. Imagination and creativity in the adolescent. In R. W. Rieber, editor, *The Collected Works of L.S. Vygotsky*, volume 5: Child Psychology. Plenum, New York, 1998.