Metaphor-Based Learning of Physics Concepts through Whole-Body Interaction in a Mixed Reality Science Center Exhibit (DRL-1417966)

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Institutional Partners: Orlando Science Center (OSC) and Museum of Science and Industry (MOSI) in Tampa, FL

Introduction

This project seeks to understand the effects of interactive and immersive environments on learning of science concepts in informal contexts. Specifically, we aim to investigate ***embodied interactions*** and whether cueing students to physically enact critical ideas in physics will support middle school students' learning, engagement, and identification with science.

This research is grounded in emerging research on the embodied nature of cognition and learning (e.g., Glenberg, 2010) and the importance of designing science learning simulations such that interactions map coherently to conceptual development (NRC, 2011).

Research Questions

1. How does the opportunity to embody elements of an immersive simulation affect a learner's propensity to experience conceptual change and develop scientific habits of mind?

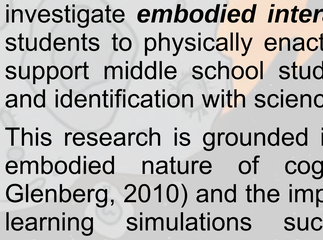
   1.1 What design features of mixed reality environments best support body metaphors?

   1.2 What metrics are most effective for assessing learning through body-based metaphors?

   1.3 What are the practical considerations to creating immersive metaphor-based learning experiences in ISE institutions such as at a Science Center?

MEteor

The primary environment for facilitating metaphor-based interactions on this project has been an environment called *MEteor*—a simulation of planetary astronomy where students use their bodies to make predictions about how an asteroid will move when it encounters nearby planets, etc. The simulation is implemented using floor-projected imagery and laser scanning technology. At our museum sites, a set of information displays were created to allow parents to help their children perform successfully in the simulation.



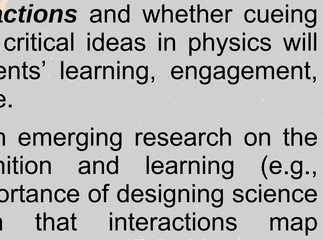


Figure 1. A student using *MEteor* at OSC (left). Information displays for parents and other visitors (right).

Challenges and Findings

Some of the important challenges faced in this project include building metaphors that students can easily and intuitively work with in the context of an interactive simulation (e.g., "I am an asteroid") and also developing appropriate learning measures that capture the effects of this unique experience (e.g., measures of student movement and adaptation). These challenges continue, but there have been several important results from the project so far, including:

Physics and Space Knowledge

Students who use the full-body version of the simulation score higher on an assessment of physics and space knowledge questions compared to a group of participants who used a desktop version of the simulation, $t(112)=2.13$, $p=.035$. This indicates cognitive advantages for embodied interaction and physically making predictions within science simulations.

Attitudes Towards Science

Students using the full-body simulation also showed higher improvements in questions about their identification and positive feelings about science, $F(2, 111) = 0.03$, $p = 0.033$.

Table 1. Categories of parent utterances of all sessions

Category		Percentage	GroupTotal
1. Instructions	aimed at launcher or child	32%	
	aimed at result	11%	
all instructions			*43%*
2. Explanations	of simulation mechanism	7%	
	linking to science concepts	7%	
3. Invitations to reflect, explain		9%	
all explanations and invitations			*23%*
4. Task		8%	
5. Affective participation		21%	
Not interpretable		5%	

Parent-Child Conversations

In the museum context we found that *MEteor* supported productive conversations between children and their parents that frequently led to successful performance. Compared to other studies of museum conversations, we found that a substantial portion of the conversations were based around simulation components and science knowledge. A breakdown of these conversations can be seen in Table 1.

Project Status and Current Objectives

This project is just concluding its 3rd year. At the end of Year 2 the project was transferred from UCF to UIUC where the focus has shifted to the development of some new simulations and a more flexible, adaptive platform for motion and gesture recognition. The aim is to create an AI-driven system that can recognize and respond to a variety of learning gestures in real time. Some images of this effort are shown in Figure 2.

Figure 2. A student using hands to represent "scaling up" (left). A collision simulation that can be controlled with gestures (middle). The *Waves* simulation installed at OSC in January 2014 (right).

A significant component of the project has remained at UCF where the focus has been examining practical issues of installations of exhibits involving whole-body metaphors in Science Centers. To conduct this investigation we have created a new interactive experience around the topic of ***Waves***. This is a collaborative game where 2 museum visitors work together to create a wave—using constructive and deconstructive interference—that meets target criteria (e.g., having a specified amplitude). We found that the visitor interaction was high and appeared to justify the large footprint of the exhibit.

References

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